AUGUST, 1948
Vol. 4 - No. 4

Lubrication ENGINEERING

JOURNAL OF THE AMERICAN SOCIETY OF LUBRICATION ENGINEERS

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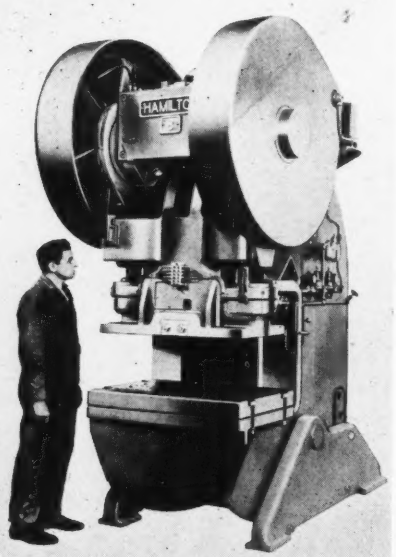

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Lubrication Engineering

VOL. 4 AUGUST, 1948 NO. 4

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A·S·L·E

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343 SOUTH DEARBORN ST., CHICAGO 4, ILL.

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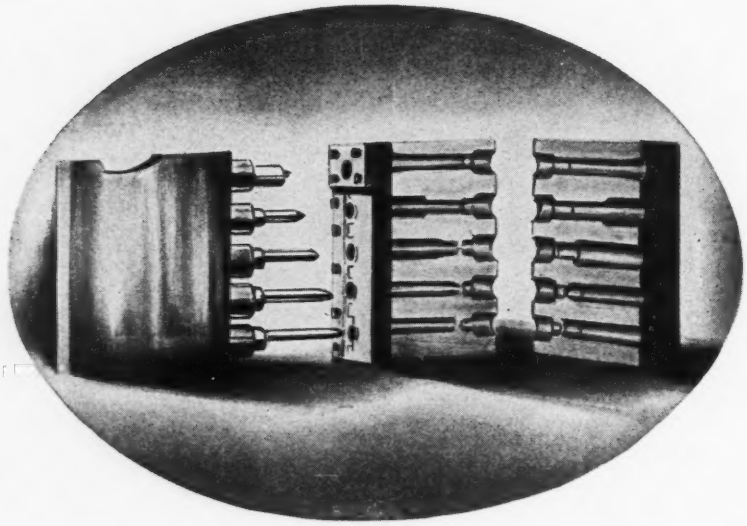

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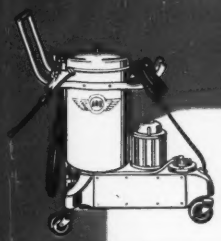

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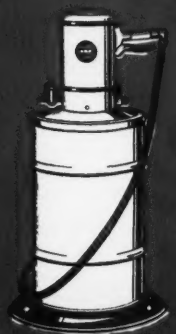

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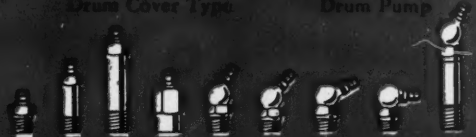

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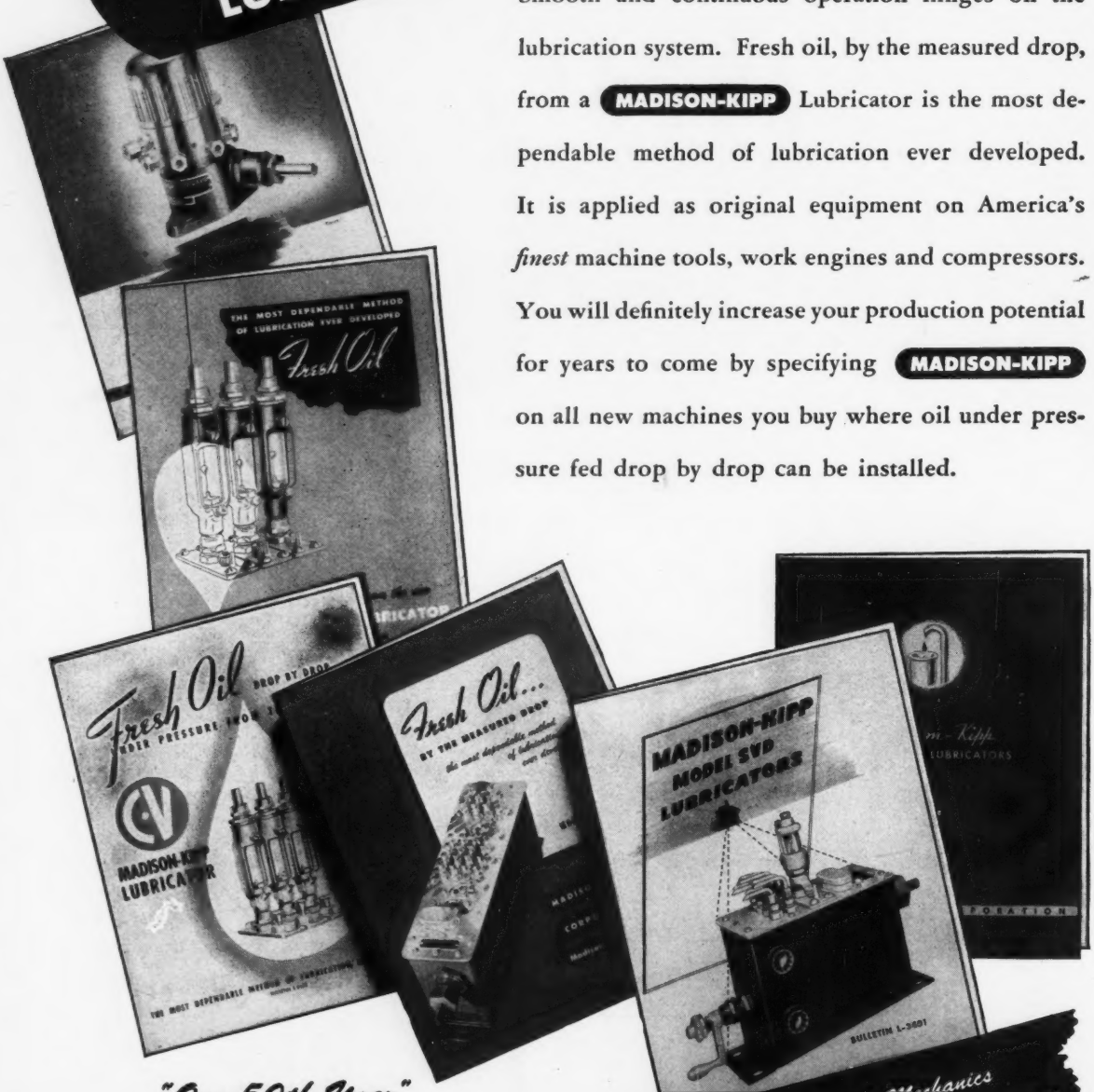

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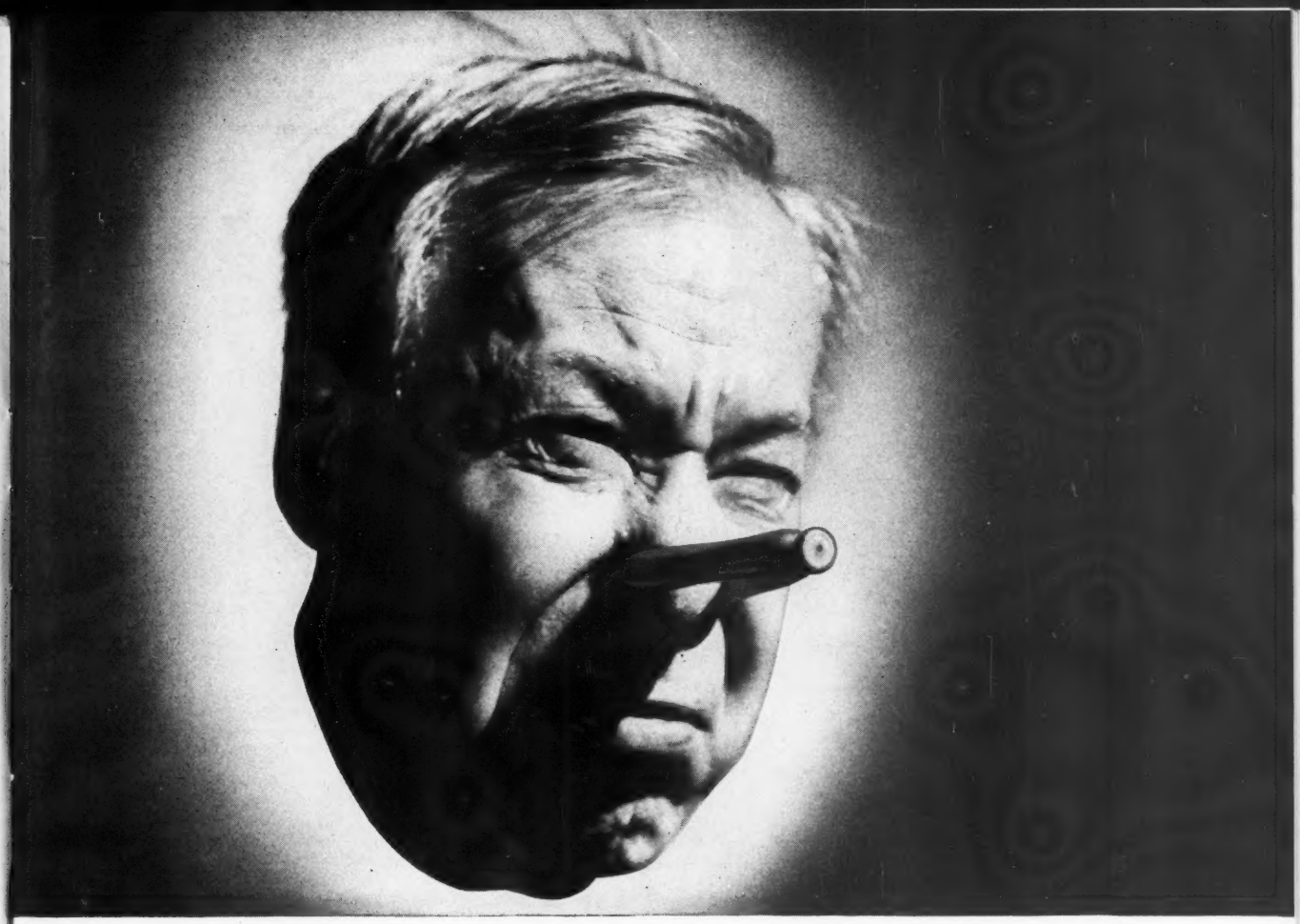

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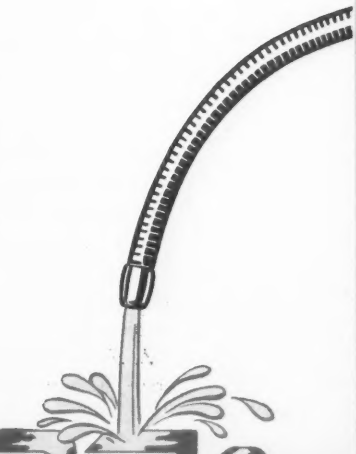

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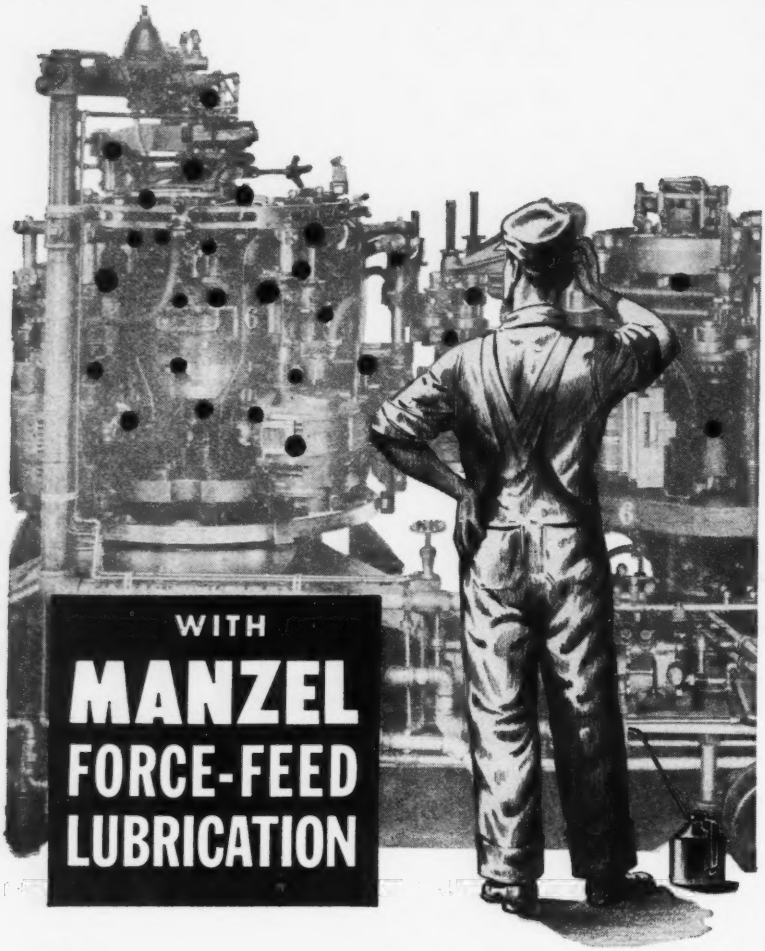

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Silicone News

DC

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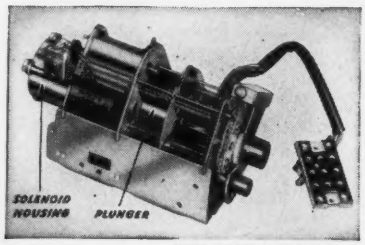

PHOTO COURTESY MOTOROLA INC.

DC 44 Silicone Grease permanently lubricates the plunger-solenoid contact surfaces in this Motorola Auto Radio push-button tuner.

Actual performance is the only true measure of a lubricant's quality. That is why more and more manufacturers are specifying Dow Corning Silicone Greases for their lubrication problems. Their tests show that longer lubrication life, greater oxidation resistance, elimination of gumming, and indifference to temperature extremes are all characteristic of the silicone greases.

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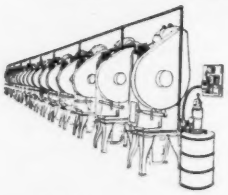

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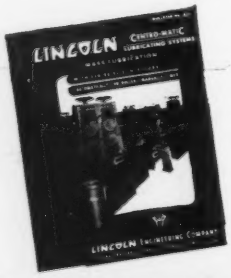

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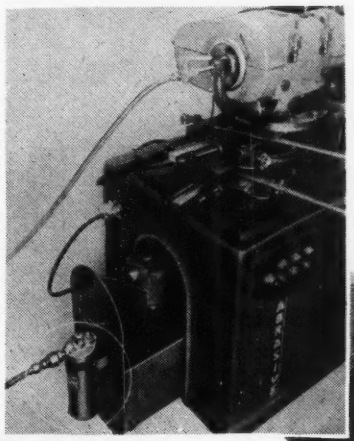

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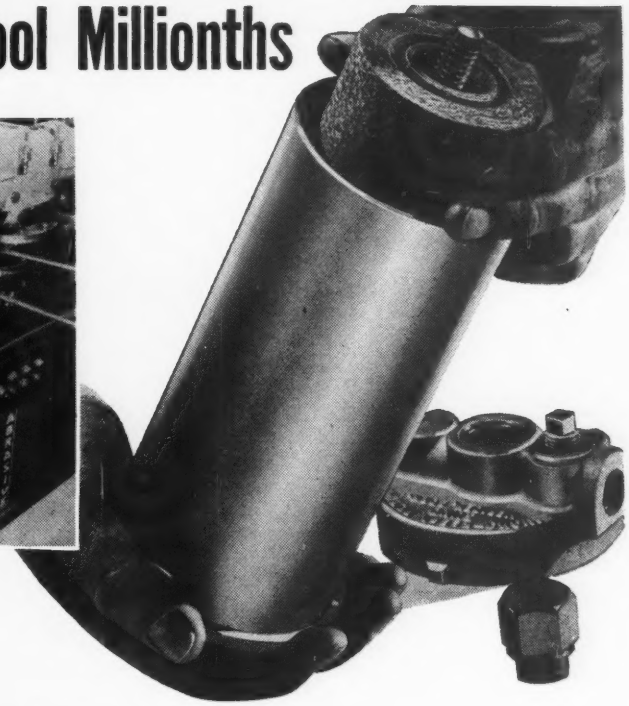

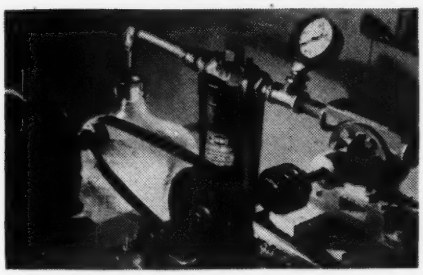

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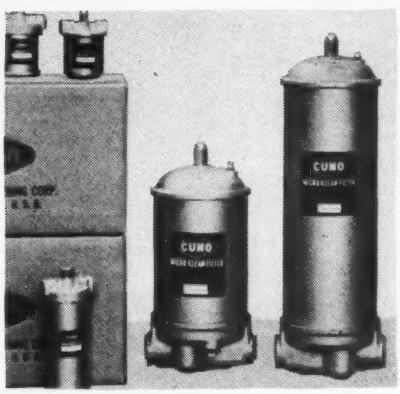

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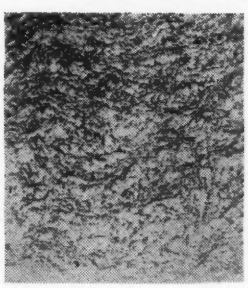

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THE EDITOR'S PAGE

YOUR Editor considers it a privilege to invite the President of the Society to present, on this page, a message to lubrication engineers and A.S.L.E.

G. L. SUMNER

"It is fitting, when a new group of officers assumes its responsibilities, to pause and take inventory. In some three and one-half years, the American Society of Lubrication Engineers has become accepted as an established force in a field of engineering which heretofore had little or no formal recognition. Three and one-half years ago, I dare say, in the whole United States there were probably not more than a score of people with the title of lubrication engineer, and there were no curricula in the colleges that would enable one to study extensively in this field. This is still true, but rapid work is under way toward training lubrication engineers at the graduate level, and in industry a much greater recognition is being given to the need of training of lubrication specialists. Certainly both of these programs need all of the encouragement that our Society and industry can possibly give to them.

"Our first A.S.L.E. book, a translation of the book by Dr. Reemt Poppinga on 'Wear and Lubrication of Piston Rings and Cylinders,' is a valuable contribution in English to the technical literature of lubrication engineering.

"A.S.L.E. is also exploring the idea of setting up, with one or more leading universities, a cooperative study of industrial problems whereby the results of fundamental research will be available to industry as a whole. For example, there is a need for knowledge in bearing design that will predict the effect of changes in bearing length, size and type of grooves on lubrication. These data are needed by the design engineer in order that he may pre-determine definite oil flow rather than correct faulty lubrication by the cut and try method.

"In this program the first step will be a study of the literature to see what information is available. This will then be classified and a bibliography for guidance can be prepared. The bearing manufacturers will be asked to participate in this research program and to share its expenses. Because the project can be centralized, the financial burden will be light when compared to the present high cost of separate individual research in many places. Many universities and research foundations indicated their willingness to undertake such a task and the offer of Columbia University to head up this research was accepted.

"Our journal, LUBRICATION ENGINEERING, has had an active and steady growth both in circulation and in content. It has changed from a quarterly to a bi-monthly publication and should change to a monthly appearance in the reasonably near future. Because of the background of the members of the Society, many articles are available to it which formerly were never written and prepared, and each of which contributes to a significant phase of lubrication or related engineering.

"Some of us do not appreciate the full breadth of the field of lubrication as it tends to become obscured in the ramifications of the many other fields which it serves. Certainly we should mention bearing fabricators, machine-tool builders, manufacturers of pumps, gears, turbines, diesels, motors, generators, the operation of steel rolling mill equipment and the very extensive field of cutting fluids.

"Our Buffalo convention was a big success. You who were fortunate enough to be there noticed the great interest in the exhibits. These exhibits were not an array of oil samples, as some people feared, but offered variety in the latest improvements and trends in lubricants, cutting fluids, lubrication systems and applicators as well as testing equipment. The exhibit was an example of team work at its highest efficiency.

"Next year we are holding our fourth national convention in New York. Already the 18th floor of the Hotel Pennsylvania has been engaged for April 11, 12, and 13, and the program committee has met to lay the foundation for presentation of both highly technical and not-so-technical papers in concurrent sessions offering a choice of subjects to our members and others interested in lubrication either in its theoretical or practical application. Space for exhibits is already being requested.

"Our conventions and exhibits are a display of showmanship, but let us not forget that our real strength lies in the success of our local sections. It is essential that they be manned by enthusiastic workers. The officers and directors recognize that national financial help is needed to insure strong local sections and steps are being taken to make this aid available for each section.

"This is a presidential election year, and the air is literally cluttered with politics. Even the cold war with Russia is being crowded into the background, at least temporarily. Another round of wage increases, though not so large as previously given, has been granted. This, in all probability, means further rise in living costs. But 'what goes up must come down'—the question is when? The answer to this question is of much importance to A.S.L.E. Our Society is young and while we have had some growing pains, our growth has been phenomenal. But speed is essential in obtaining a firm footing that will enable us to withstand any economic storm that may appear on the horizon. With your active interest, help and guidance, I am confident that we can steer our ship safely into port."

G. L. SUMNER,
President, A.S.L.E.

Water-Mixtures as Grinding and Cutting Fluids*

By WILLIAM H. OLDACRE

D. A. Stuart Oil Co.

FROM its very beginning, the history of metalcutting has indicated the use of both water mixtures and straight oils for cutting fluids. Water was used very early in abrasive operations, and it is probable that Stone Age artisans benefitted from the discovery.

When the introduction of ferrous metals in machinery made rusting a problem, sal soda, the then most available alkali, was dissolved in the water as a rust inhibitor. The spindles and slides of early metal-working machines were lubricated with fluid fatty oil, and naturally, when occasion seemed to indicate a need for lubrication at the tool point, these oils were so applied. When the invention of the slide rest and other machine improvements made possible more continuous production, the function of the cutting fluid was emphasized, and apparently the use of both water-mixtures and straight oils was extended.

The development of high speed steels and the increased machining speeds which resulted from their use in cutting tools made temperature control an evident necessity, and water-mixtures received increased attention. Taylor, especially, in his epochal work records the benefits of a flow of "water" almost to the exclusion of any other cutting fluid consideration.

It is not clear just when the first crude emulsions were formed by mixing soda water with fatty lubricants, and the commercial development of soluble oils is almost entirely neglected by history. It is apparent, however, that water-mixed emulsions have been very widely used in metalcutting for more than half a century, and in a wide variety of formulations have made very important contributions to machining practice.

Unfortunately, careless reference and inaccurate terminology interfere with an accurate appraisal of the record, so we can never be sure what is meant when "water," "soda water," "soap water," or "soluble oil" is mentioned. The record of current practice is likewise confused by inaccurate terminology, and even further by the tremendous complexity and the rapid development of our modern industrial metalworking plant.

Nearly everybody recognizes the need for more factual information, but few have either the time or the inclination to separate the thread of fact from the snarled skein of conflicting reports. In spite of this, however, with so little sound theory and even less scientific truth to deal with, we are forced to rely on an appraisal of history and current practice.

The use of both water-mixtures and straight oils still continues accompanied by much fruitless argument regarding their respective merits and costly speculation regarding the possibilities of their performance. Lacking accepted hypotheses for the mechanisms of metalcutting, it is perhaps futile to contemplate any comprehensive appreciation of cutting fluid functions, but much may be learned from an orderly analysis of everyday cutting fluid practice.

*Presented at 3rd Annual Convention of A.S.L.E., April, 1948, Buffalo, N. Y. Member of A.S.L.E.

The invitation to prepare this paper was accompanied by the statement from a leading industrial engineer as follows: "The lubrication committee of my company goes on record that they are more in need of information on emulsifying oils and compounds than anything else in the lubrication line."

Realizing that this statement will be echoed by a large number of industrial and lubricating engineers, this paper will neglect any consideration of straight oil cutting fluids, and will attempt to survey and perhaps in some measure analyze current machine practice as it is affected by water mixtures.

The emulsions have been very popular for many years and there is every reason to believe they will occupy a leading position for many more years. Long experience has established their advantages and has acquainted us with their shortcomings. They have stood the test of time. They are reasonably presumed to possess at least some of the advantages of both oil and water. However, the use of the term "emulsions" is a dangerous over-generalization and we must recognize the wide variation possible in their formulation and anticipate corresponding differences in performance.

For the sake of brevity, and at the risk of oversimplification, it may be stated that an emulsion is a dispersion of one fluid in another, and ordinarily in the case of cutting fluids the emulsion is promoted and stabilized by an emulsifying agent. The dispersed fluid is usually an oil and may be of almost any type. If it is presumed, as would reasonably appear, that the nature of the oil will affect the performance of the emulsion as a cutting fluid, the appearance in this dispersed phase of almost every type of product which has been found of value as a straight cutting oil is reasonable and logical. Petroleum oils, fatty oils, sulphurized oils, and chemically processed oils, all of which have estabished values in the field of metalcutting, can therefore be expected to appear as the dispersed phase in emulsifiable oils. It must not be too easily assumed, however, that all of the qualities which are evident when these products are used in the oily form, will be effective to the same degree in the emulsified form.

Emulsifiers used in cutting oils are limited in number. Usually they are simple soaps of either petroleum or fatty derivation, or the sulphonate soaps from the same sources. Sodium and potassium soaps of fatty and rosin acids have in the past found wide application and formerly fatty oil sulphonates were used to a considerable extent. Today, however, the rather complex organic sulphonates derived from petroleum are in very general use and seem to possess some advantages in respect to rust inhibition, stability and all-round performance that give them a well-earned preference. Simple soaps form the basis of most paste compounds, and find wide application, especially as drawing compounds.

The commonplace soluble oil is really a remarkable product. In appearance a rather ordinary oil, it is in

fact a precisely balanced compound of oils, soaps and solvents. It takes a great deal of abuse and has the truly remarkable property of forming a homogenous emulsion almost spontaneously when mixed with water. When properly manufactured, the soluble oil produces an emulsion of remarkable uniformity and great stability. These and other desirable qualities are the result of careful and experienced formulation, and therefore, their advantages are not always apparent from a routine laboratory analysis.

The emulsion itself as used on the machine is likewise remarkable. As usually considered, an emulsion consists of an outer phase, an inner or dispersed phase, and a protective phase. The outer phase is usually a soap-in-water solution, while the inner phase may be oil or oil with a small amount of dissolved soap. The protective phase probably is soap with possibly a little water and oil dissolved in it.

Any extended discussion of the nature of emulsions is beyond the scope of this paper, but it should be noted that an emulsion is generally considered to be governed by its outer phase, thus oil-in-water emulsion, in which water is the outer phase and to which class most cutting fluid emulsions belong, will water-wet surfaces with which they come in contact; while a water-in-oil emulsion will oil-wet the surface. A common test, therefore, for emulsion type is to bring it in contact with a piece of filter or blotting paper. If the paper is water-wet, an oil-in-water emulsion is indicated; if a grease spot develops, indicating that the paper is oil-wet, we may presume a water-in-oil emulsion.

Cutting fluid emulsions are usually dilute, with from 15 to 100 parts of water for each part of soluble oil. This heavy dilution makes the task of analyzing a finished emulsion rather difficult. A 25-1 mixture of soluble oil contains only 4% of the original oil of which possibly 15-20% is soap or emulsifying agent. There is, therefore, not over 1% of emulsifier or soap in the emulsion, and obviously it is not too easy to check slight variations which may develop from use or from faulty compounding.

While emulsions are rather easily broken down by the additions of salts or acids, and such procedures form the basis for routine concentration tests, contamination from machine oils, slushing oils, and other foreign materials with which they come in contact frequently affects results to a degree that renders them undependable.

Most emulsifying products contain some water as an original constituent, and if this separates either by evaporation, freezing or as a result of faulty formulation, the product may be injuriously affected. Formerly ethyl alcohol was used as a coupling or stabilizing ingredient in many soluble oils, and, due to its low boiling point, was apt to evaporate to the detriment of the material. The development of satisfactory higher boiling alcohols and glycols has made it possible to eliminate this hazard.

The emulsion as used on the machine is in large part water, and many of the difficulties that occur in practice are traceable to the water source.

As the major component in every water-mixed cutting fluid, the water deserves a great deal more attention than it usually gets. True, we hear much discussion about hard water conditions and their effect on the mixing of soluble oils, but hardness, as ordinarily considered, is not the only contaminant or impurity in water which may affect the performance of cutting fluid mixtures. Of course those metals such as calcium and magnesium which form insoluble soaps, interfere with proper emlusification due to the removal of some of the soap

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from the mixture. However, this condition can be rather easily counteracted usually through the use of well-recognized softening agents. One thing should be noted in this connection; it is always cheaper to use a simple alkali water softener rather than the more expensive soluble oil soaps for this purpose.

Water analysis as usually practiced deals either with the suitability of water for home and human consumption, or its use as boiler feed water, and rarely is any attention given to elements which may seriously affect cutting fluid performance. As so little attention has been paid to them, we are unacquainted with many, but from experience we may safely draw some conclusions.

Iron and iron salts are present in most waters. The amount varies from a trace to as high as six parts per million. Most well water tends to be fairly high in this element, averaging perhaps from 2.5 to 4 parts per million. The iron content of water used in mixing soluble oils undoubtedly has an important effect on the rust accelerating or inhibiting characteristics of the finished mixture. Frequently the presence of iron in the original water indicates the presence of other elements which are conducive to the solution of iron or the production of iron salts, and, therefore, when in operation the mixture is in continuous contact with ferrous material, much larger percentages of iron will go into solution. When the water is evaporated on the surface of the finished product, the iron salts are frequently deposited in a form which ultimately turns to oxide and promote rust. Sulphides including hydrogen sulphide are a class of compounds which seem to contribute to this condition. Sulphides, of course, promote a reducing solution and are usually accompanied by bicarbonates and similarly unsaturated compounds. Ferrous salts are more soluble than the ferric and, therefore, in the reducing condition more iron will go into the solution to be later deposited.

Algae, bacteria and other organic matter found frequently in natural waters can and often do affect the cutting mixture objectionably. Bad odor, separation and rusting are frequently traceable to these sources. While the effect of the "iron eating" organisms has not been thoroughly investigated, it is probable that such organ-

isms as crenothrix, spirophyllum, leptothrix, dydymohelix and siderocapsas contribute to many baffling rust problems. According to Tourneau and Russel, the content of waters should not exceed .3 parts per million if trouble from iron depositing organisms is to be avoided.

The effect of all these contaminating influences is intensified by concentration due to the evaporation of water in the normal operation of the machine. In addition, there are many salts found on the surfaces of metals, particularly forgings and castings, which are water-soluble and wash off to accumulate in the cutting fluid. It probably need only be mentioned that alkalis and other salts from washing compounds, where rinsing processes are inadequate, may contribute to the contamination of cutting fluids in following operations. Here again we should not forget that with a very small amount of soaps or other emulsifying agent responsible for the maintenance of the emulsion a correspondingly small amount of contamination is required to neutralize the effect of the emulsifier and produce difficulty.

While in this discussion of contamination we have been dealing with emulsions, the same observations

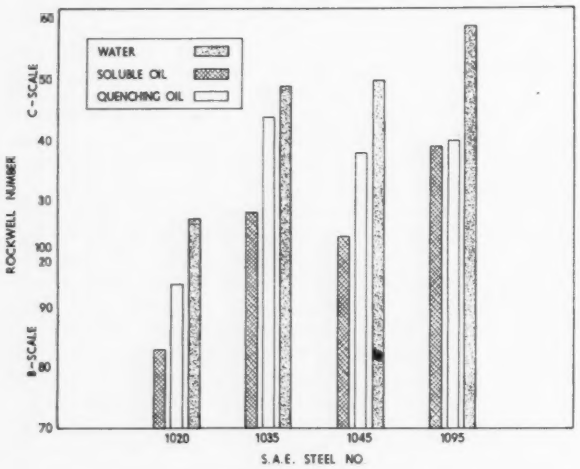

Fig. 1

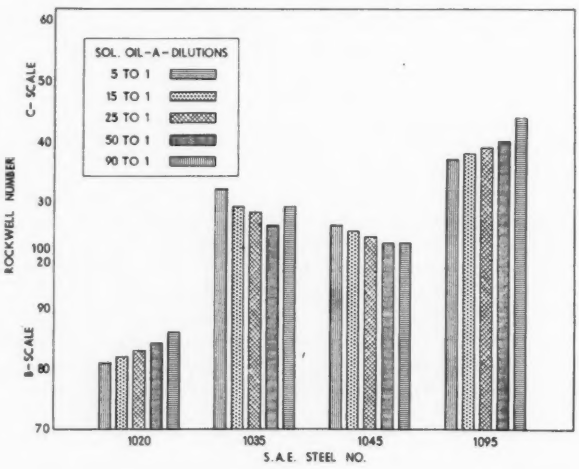

Fig. 2

apply to other types of water-mixture. Dispersions of various sorts are similar in many respects to emulsions. Pigments, whiting, talc, chalk, zinc oxide, graphite, mica and mica-like materials, waxes, water insoluble soaps, and many other solid materials are frequently found in drawing compounds and occasionally are used in metal-cutting operations. The tendency of the dispersed solids to separate and frequently to deposit in bearings and working areas of machines, is a serious objection to the use of such products in precision metalcutting. When they are used the effect of contaminating materials is perhaps more pronounced due to the absence of a lubricating oily residue.

The residues from simple salt solutions such as soda ash and the various phosphates are, of course, in themselves solid and probably the addition of a little more contaminating material does not add to their tendency to form objectionable deposits. The use of such solutions by themselves is extremely limited and scarcely deserves further attention.

Frequently, questions are raised regarding the testing of soluble oils, emulsions, and other water-mixtures, either for the purpose of checking the supplier or of maintaining uniformity in operating procedures. With such a limited understanding of the mechanisms of metal cutting and cutting fluid performance requirements, it perhaps follows naturally that we have few applicable and satisfactory tests. Customarily, the first test of an emulsion is for stability. The original product is mixed under standard conditions and allowed to stand for a period, when the amount and type of separation, if any, is noted. Usually the material that separates least is considered the best, but actual experience indicates that a slight amount of oily separation may benefit performance. This fact may be demonstrated if on a difficult job where finish is a factor a minor amount of fatty oil or other cutting oil is added to a soluble emulsion. Apparently the cutting oil is simply carried with the emulsion to the tool orbit and there performs its usual function. Of course, separation tends to non-uniformity of performance, and there is no intention here to defend excessive or uncontrolled separation.

Probably the popularity of many paste compounds lies in the fact that there is a certain amount of separation, either oil or water-in-oil emulsion, which functions in the manner just mentioned. The presence of a water-in-oil emulsion in the main oil-in-water product is usually indicated by "creaming." The term is aptly descriptive as cream is a water-in-oil emulsion which separates from milk, and when a water-in-oil emulsion is present in a water-mixed cutting fluid, it separates on standing in a similar manner.

Frequently it is the practice to apply routine chemical analysis tests to soluble oils, determining the type of oil, the type of soaps, and perhaps the total volatile material present. Properly interpreted the information so derived is of value, but, with no correlation between chemical tests and service performance, such tests must be handled with caution.

Other than the routine observing and recording of factory machine operation, there are almost no factory testing procedures worthy of mention. In actual fact the so-called test is usually so poorly conceived and carelessly supervised as to belie the name.

Frequently the fact that an operator is under observation will upset his normal procedure to a point where the validity of his results is open to question. Operators hate to be bothered but are anxious to please, and if

Note: Figures marked (1) and (2) give hardening data on respective steels quenched with various media as indicated under governed conditions.

the boss wants a detailed record he usually gets it, but often it is not a record of fact. Rarely is the cutting fluid test conducted under trustworthy conditions with trained observers and scientifically skilled supervision.

How then shall we test water-mixed cutting fluids and what factors may we reasonably assume to have a bearing on their performance. First, the supplier should be tested. Is he reliable, experienced, honest? While a reasonable allowance can be made for "poetic license" in salesmanship, intelligent appraisal will in most cases easily reveal the validity of salesmen's claims. Too often the purchaser assumes that guile is the accompaniment of experience, and that the experienced supplier is too smart to be trusted.

TABLE 1 — SECTION 1

WATER CHARACTERISTICS

Analysis (Parts per Million)

City	Total Dissolved Solids	Fe	Ca	Mg	HCO_3	Total Hardness
Cincinnati, Ohio	207	.05	34	6.1	45	110
	258	.05	42	6.1	52	130
	172	.05	30	5.3	43	97
	407	.03	60	12.0	52	200
	133	.05	21	3.8	29	68
Lansing, Mich.	394	.91	108	32.0	392	401
	341	.74	76	27.0	364	301
	296	.85	69	22.0	322	263
	386	.63	93	34.0	402	372

TABLE 1 — SECTION 2

City	Total Dissolved Solids	Fe	Ca	Mg	HCO_3	Total Hardness
Buffalo, N. Y.	147	.01	34	8.0	109	118
Cleveland, Ohio	159	.24	34	8.6	104	120
Boston Mass.	43	.12	4	1.0	16	15
Chicago, Ill.	157	.20	34	9.7	146	125
Chicago Hts., Ill.	818	.40	136	66.0	473	611
Flint, Mich.	358	.00	70	30.0	248	298
Pontiac, Mich.	346	.78	66	26.0	349	272
Philadelphia, Pa.	155	.03	25	9.0	50	99
Pittsburgh, Pa.	291	*	31	8.0	10	117
San Francisco, Cal.	195	2.20†	35	13.0	176	178
Santa Barbara, Cal.	660	.41	136	20.0	357	422

*Varies from .01 to 7.9 from different sources at supply and season.
†Includes both Fe and Alum.

TABLE 2

ANALYSES — SOLUBLE OILS

Lab. No.	% Soap	Water	Min. Oil	Fatty Oil	Pigment
382	28	5	68		
392	26	14	44	16	
397	16	56	31		
404	25	8	62	5	
405	13	3	65	21	
413	35	65			
420	12		82		
441	6	22	65		
475	10	70		13	
485	20	3	53		

TABLE 3

ANALYSES — PASTE COMPOUNDS

Lab. No.	% Soap	Water	Min. Oil	Fatty Oil	Pigment
321	13	41	34	12	
418	26	57			17
477	10	24		25	40
493	20		65	5	10
A654	11	38	Und.	21	
A673	15	50	Und.	30	
A691	19	30	20	31	

Next, the price should be tested. With some knowledge of the materials apt to be found in cutting fluid compounds, and with information regarding the cost of such materials easily available, an intelligent appraisal of price is possible for almost any purchaser. Obviously no competent supplier is going to sell a product at a loss or on the basis of an inadequate profit. An inordinately high price on the other hand must give rise to a demand for sound explanations and proofs of performance.

Inspect the product. Too often this simple procedure is neglected. The senses, sight, taste and smell are invaluable aids in the investigation of almost any material.

Stability tests should not be overlooked. The original material should be allowed to stand and any tendency toward separation, segregation or sedimentation should be noted. Mixtures with water should be made according to instructions and allowed to stand for a suitable period. The appearance of the mixture will give many clues as to the composition. Good emulsions, of course, have a tendency to form an opaque blue-white emulsion unless the color is affected by unusual coloring in the oil or emulsifier content. Translucency indicates a higher soap and lower oil content with less emulsion and more solution present. Absolute transparency indicates almost no emulsion. The presence of dyes or other coloring is usually easily observed and needs no comment. The behavior of the mixture after standing should be carefully observed. Oily and creamy separations should be considered and evaluated. If the separation is so complete as to leave a watery remainder, trouble from rusting may be anticipated.

A routine chemical laboratory analysis is probably next in order and can be very helpful, although, as has been said before, care must be used in interpretation because of the lack of correlation with service. Attention should be paid to the quantity and types of soap or emulsifying agent, the amount of water or other volatile materials, the amounts and types of oils present, and, if indicated, the quantity or type of solid or pigmented material. Some laboratories investigate the pH value of the finished mixtures, and it has been found in experience that pH values of 8.5 or above tend to reduce rusting difficulties.

No test for rusting has been developed to a point of wide acceptance. Over a period of years we have used a rather simple test with some degree of success. A measured amount of used steel shot from a "sand blast," sufficient to form an area of about the size of a half dollar on a watch glass, is barely wet with some of the solution to be tested, dropped from a pipette. Protected from any unusual atmospheric condition, it is allowed to stand and inspected periodically with a magnifying glass. Rust will frequently be apparent around the edges of the shot and through the bottom of the watch glass in a comparatively short period. Of course, such a test must be standardized and calibrated in the light of individual experience before it assumes any real value.

Frequently, mention is made of the wetting out characteristics of water-mixtures. While here again we have little service correlated experience to guide us, it may be reasonably assumed that this characteristic does have some bearing on metalcutting performance, and even more probably affects the behavior of fine chips in their relationship to the cutting fluid. This factor is considered of importance in dealing with grinding fluids, as whether the chips float or sink or remain in suspension is of some moment. Such behavior is undoubtedly affected by the nature of the chip produced and the foam forming characteristics of the solution as well as by wetting qualities. Curly hairlike chips will tend to felt or mat and float more readily than will heavier, chunkier chips which sink to the bottom.

The well known property of foam to float solid par-

(*Continued on page* 186)

Some Vibration Aspects of Lubrication*

By A. C. HAGG

Westinghouse Electric Co.

ABSTRACT

The role of bearings in forced and self-excited vibration of machines is discussed. The important influence of oil-film damping in limiting vibration amplitude at resonance is shown by a practical example. The effects of various bearing parameters on oil-whip are illustrated in chart form.

Mr. A. C. Hagg is engaged in research work at the Westinghouse Research Laboratories in East Pittsburgh. He graduated from the University of Wisconsin in 1939 and his main research has been in the field of mechanics. He is a member of A.S.M.E.

Introduction

THE vibration characteristics of a machine are influenced to more or less extent by bearings and lubrication phenomena, and in many cases the form or application of bearings is governed by this consideration. As an obvious example reference can be made to the axial placement of bearings along a chart or rotor which has primary effect on the critical speed of the rotating part. In many cases lubricating films exert a very positive and beneficial effect in minimizing vibration so that an otherwise serious problem has thus been resolved—very often unknowingly. Another effect in lubrication is the creation or control of energy sources which is manifest in self-excited vibration; in this category oil-whip and chatter are familiar examples.

If the present discussion can improve our understanding of some of these vibration phenomena, and thereby aid in reducing vibration troubles due to the form or application of bearings, its purpose will be achieved.

Forced Vibration and Critical Speeds

Damping is probably the most important dynamic property of a lubricating film. This damping is effective in limiting vibration of rotating machines due to unbalance and partially so at the critical speeds. Indeed, it appears that oil-film bearing damping can alone account for the relative ease with which many classes of heavy machinery pass through critical speeds, even without unusual refinements in balance.

Lubricating films also have elastic properties† in the sense that a journal deflects with respect to the bearing when load is applied. This elasticity reduces the value of rotor critical speeds under those determined on the basis of simple support at the bearings, although the reduction is limited by damping. A simple rotor system with oil film bearings is illustrated dynamically in Fig. 1 where spring and damper elements represent the lubricating films.

The unbalance vibration of the rotor mass m of the system of Fig. 1 in the first or lowest mode (lateral motion) is given by Equation (1) and can show the influence of film elasticity and damping.

$$\frac{X}{\epsilon}=\frac{\frac{\omega^2}{\omega^2_n}\sqrt{\left(\frac{2B}{K_s}+1\right)^2+\left(\frac{2\omega C_o}{K_s}\right)^2}}{\sqrt{\left[\frac{2B}{K_s}\left(1-\frac{\omega^2}{\omega^2_n}\right)-\frac{\omega^2}{\omega^2_n}\right]^2+\left[\frac{2\omega C_o}{K_s}\left(1-\frac{\omega^2}{\omega^2_n}\right)\right]^2}}$$

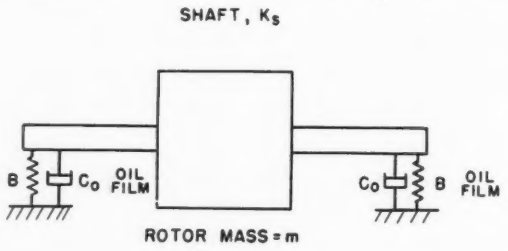

FIG. 1 ROTOR SUPPORTED BY OIL-FILM BEARINGS

where

X=vibration amplitude of mass m (in.)
ϵ=eccentricity of the C.G. of rotor (in.)
ω=rotational speed (rad/sec)
ω_n=natural frequency of rotor with simple support at the bearings (rad/sec)
B=lubricating film "spring constant" (lb/in.)
$K_s=m\omega^2_n$=shaft spring constant (lb/in.)
C_o=lubricating film damping constant (lb-sec/in.)

To make use of Equation (1) we shall first have to gain some idea of the magnitude of oil-film damping and elasticity. Damping can be evaluated with fair accuracy by methods already described.[1] The elastic properties of oil-films, on the other hand, are obscured in general by the wide disagreement of load-deflection characteristics of journal and bearing as determined by

† Reference here is made to a property of the film, and not to the elastic bulk property of the lubricant as a fluid. The elasticity of liquids is negligible in its effect on the elasticity of the film.

* Presented at 3rd Annual Convention of A.S.L.E., April, 1948, Buffalo, N. Y.

[1] See author's paper "Influence of Oil-Film Journal Bearings on the Stability of Rotating Machines," Transactions A.S.M.E., 1946, p. A214.

various investigators; however, it appears that the data of Needs on the 120° clearance bearing are of sufficient quality for significant calculations. Fortunately the 120° clearance bearing is probably representative of average practice in the line of partial bearings.

The calculated "spring constants" and damping for the 120° bearing are given in dimensionless form in Figs. 2 and 3. It can be noted that the dimensionless "spring constants" $\left(\frac{C}{Ap}\right)B$ tend to become constant at the higher values of $\left(\frac{D}{C}\right)^2 \frac{\mu N}{p}$. At lower values of $\left(\frac{D}{C}\right)^2 \frac{\mu N}{p}$ the quantity $\left(\frac{C}{Ap}\right)B$ decreases for horizontal motion, and increases for vertical motion. The dimensionless damping for per unite vibration amplitude $\left(\frac{C}{Ap}\right)\omega C_0$ increases with an increase in $\left(\frac{D}{C}\right)^2 \frac{\mu N}{p}$ but at a decreasing rate. The ratio varies over a range of about 1 to 3.

To consider a specific example, assume the rotor system of Fig. 1 to be as follows:

Rotor weight, mg=20,000 pounds

Natural frequency, ω_n=200 rad/sec (1910 rpm)

Effective shaft spring constant, $K_s=m\omega^2{}_n=2.07\text{x}10^6$

Bearing Area, A=100 sq. inches

Bearing pressure, p=100 psi

Length-width ratio, $\frac{l}{w}=1$, l=10 in. and w= 10 in.

Bearing clearance, C=.016 in. on diameter

Lubricant viscosity, $\mu=3.5\text{x}10^6$ reyns (approx. 100 SSU) in the range of 1910 rpm

Operating variable (1910 rpm), $\left(\frac{D}{C}\right)^2 \frac{N}{p}=26$

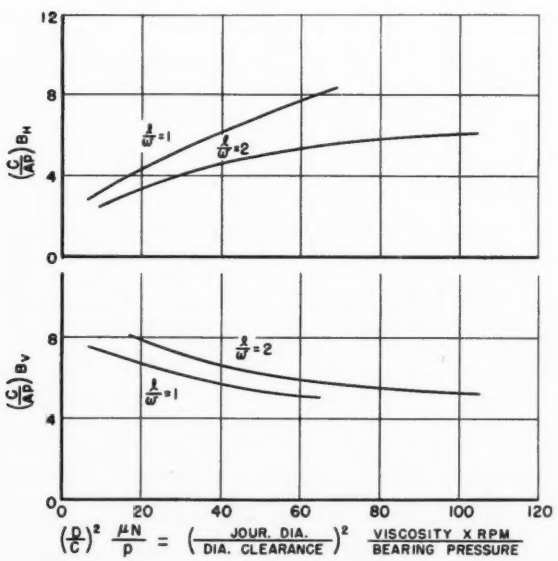

FIG. 2 OIL FILM "SPRING CONSTANTS" 120° BEARING

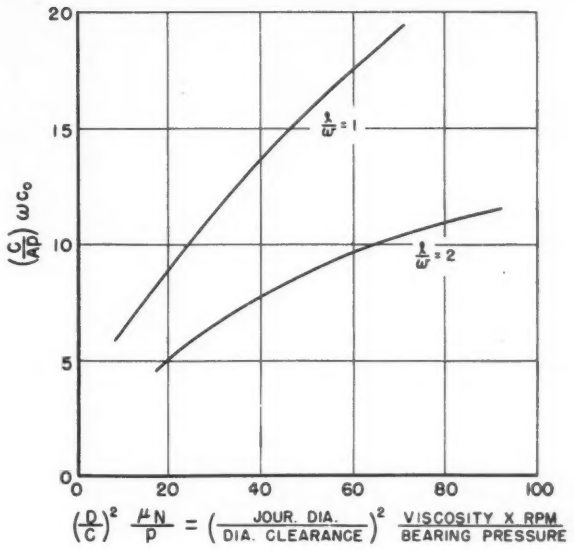

FIG. 3 DAMPING IN 120° CLEARANCE BEARING

Since the speed range of most interest is in the vicinity of ω_n=200 rad/sec (corresponding to $\left(\frac{D}{C}\right)^2 \frac{\mu N}{p}=26$), from Fig. 2, $\left(\frac{C}{AP}\right)B_H$=5.0 (horizontal), and $\left(\frac{C}{AP}\right)B_l$=6.4 (vertical), and these assumed to be constant over a moderate range in speed on either side of 1910 rpm. From Fig. 3 the dimensionless damping constant $\left(\frac{C}{AP}\right)\omega C_0$ is about 10.5. For representative values of the quantities appearing in Equation (1) we might then take $\frac{2B}{K_s}=4$, and $\frac{2\omega C_0}{K_s}=6$, and thus gain a picture of the vibration of the system at and near resonance.

The results of the calculation are shown in Fig. 4. The dashed curve to the right represents the rotor vibration assuming simple support at the bearings and with zero damping. The dashed curve at the left represents the rotor vibration with zero damping but with the film elasticity included. The solid line corresponds to the actual case and shows the combined effect of oil-film damping and elasticity. The most important point to observe here is that film damping alone of the magnitude expected in bearings reduces the maximum vibration to a practical level. It can also be noticed that the frequency of maximum amplitude is reduced in this case by about 4%.

While this calculation is admittedly crude it serves to illustrate the powerful effect of lubricating films on the unbalance vibration of rotors. Over the range of bearing practice and size of rotors, it appears that such vibration response as illustrated above is not materially altered. It is expected that bearing misalignment effects, which might also be due to heavy unbalance and vibration, would make the vibration response less favorable.

In contrast to oil-film bearings, the damping in ball or roller bearings is small, and consequently they are not well adapted to handle unbalance vibration in

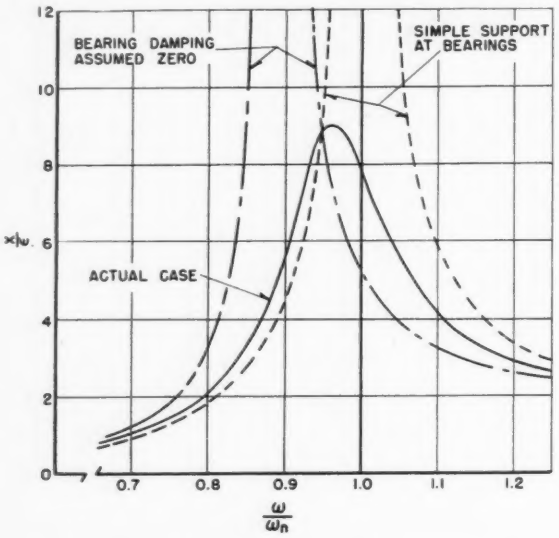

FIG. 4 ROTOR VIBRATION AT RESONANCE

many heavy duty applications especially at critical speeds. Designs employing these bearing types usually require special attention with respect to balancing; in many cases they appear to be wholly unsuitable, because vibration conditions would materially reduce their life and impair machine reliability.

Force frequencies other than running frequency often must be considered. Multiple element thrust bearings of the Kingsbury type for example give rise to force frequencies equal to the RPM times the number of shoes. In this case forces may be of sufficient magnitude to excite any resonant or near resonant members in the machine. Force frequencies associated with the number of balls or rollers in a bearing may lead to vibration troubles and often is a means for detecting a failed or other wise unsatisfactory bearing.

Poor alignment of bearings not only impairs their normal load carrying functions and reliability, but also with the otherwise normal amount of unbalance vibration may cause a hot spot on the journal which in turn humps the rotor causing greater vibration so that the machine has to be shut down. Other vibration phenomena which may be due to misalignment and of self excited type will be considered in the next Section.

Self Excited Vibration

A self-excited vibration known as oil-whip occurs not infrequently in machines employing oil-film bearings. Usually the rotor is the major vibrating element although the instability may be manifest to the same or greater degree in non-rotating parts; the forces doing work in support of oil-whip come from oil-film pressures. The vibration is characterized by relative motion of journal and bearing in an area enclosing path usually circular or elliptical, and in the direction of machine rotation. The motion is often magnified in adjoining machine parts due to resonance. The frequency of oil-whip is invariably less than one-half running frequency, which is an important characteristic especially useful for identification purposes. Fig. 5-a is a trace of a typical oil-whip record; in this example the oil-whip frequency is about 0.45 running frequency.

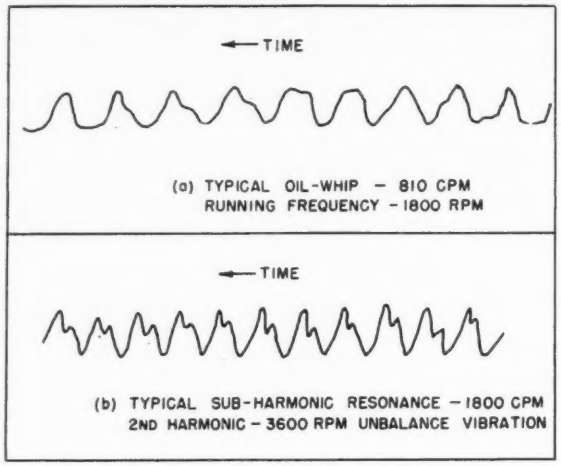
TIME
(a) TYPICAL OIL-WHIP – 810 CPM
RUNNING FREQUENCY – 1800 RPM
TIME
(b) TYPICAL SUB-HARMONIC RESONANCE – 1800 CPM
2ND HARMONIC – 3600 RPM UNBALANCE VIBRATION

FIG. 5 TRACES OF VIBRATION RECORDS

A complete understanding of oil-whip is made difficult by the complicated nature of even the simpler machines and of the properties of lubricating films; however the influence of various parameters of clearance bearings on stability is fairly well knokn. These influences can be shown almost completely in curve form as given in Fig. 6. In this curve the condition of stability or instability is outlined into regions on the plot of parameters $\left(\frac{D}{C}\right)^2 \frac{\mu N}{p}$ and CN^2.‡

Examining Fig. 6 the effect of speed is clearly apparent by the factor N and N^2 in both parameters which with their increase leads to unstable conditions eventually. The effect of clearance is quite interesting; it can be noted that a given change may or may not

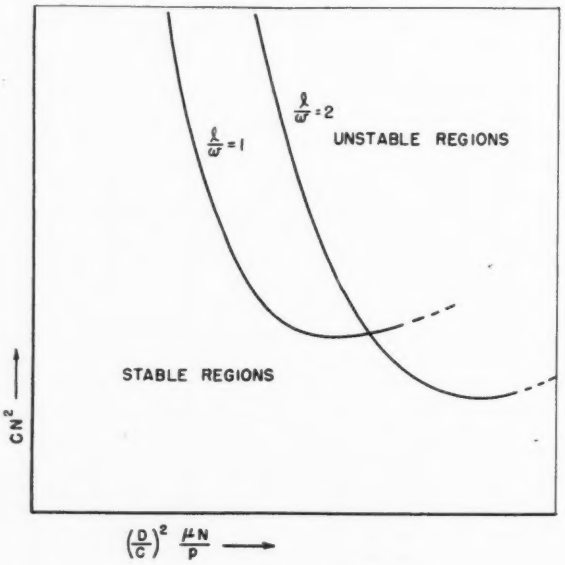

FIG. 6 STABILITY CHART

‡ The parameter CN^2 results from theoretical considerations as outlined in a previous paper. (Ref. 1.)

change stability conditions depending upon the original operating point. For a position in the unstable region near the upper section of the transition line an increase in clearance evidently leads to stability. For an operating point in the same region near the lower right section of the transition line, an increase in clearance apparently would not help, but a decrease in clearance would lead to stability. Other unstable operating conditions can be noted where either an increase or decrease in clearance should lead to stability. Such effects of clearance as noted have been observed in practice.

The effect of increasing the $\frac{l}{w}$ ration by circumferential grooving is known and has been used as a powerful means to eliminate oil-whip; this indication is clearly apparent in the curve. The stabilizing effect of increased bearing pressure or decreased lubricant viscosity (increased bearing temperature) have long been known[2] and are shown in the curves by the resulting decrease in $\left(\frac{D}{C}\right)^2 \frac{\mu N}{p}$.

In some cases stability is difficult if not impossible to achieve using conventional oil-film bearings, hence it becomes worth noting that the pivoted shoe or pad journal bearing is inherently a stable type. This bearing is not only incapable of exciting or maintaining a vibration but also offers heavy damping to forced vibration as caused by unbalance. This damping is effective in overcoming other unstabilizing influences arising outside the bearing.

Subharmonic Resonance. Another type of self-excited vibration often occurs in rotating machines which can result from bearing conditions. This vibration known as sub-harmonic resonance is characterized by its fundamental frequency which occurs at exactly one-half, one-third, or any other submultiple of running speed; usually, however, the frequency ratio is one-half or one-third. In the record of a typical subharmonic vibration shown in Fig. 5-b the running speed appears as a second harmonic, so that the fundamental frequency of the self-excited motion is one-half running frequency.

Subharmonic resonance can be maintained by periodic contact of journal and bearing which can occur through combination of poor bearing alignment or excessive bearing loading, and unbalance vibration. Contact of bearing and journal leads to a non-linear system with the motion containing higher harmonics; a disturbance (unbalance vibration at running speed) can do work on one of these harmonics and maintain the complete non-linear motion. To be sure, the source of energy for the vibration does not originate in the bearing; however, even with moderate unbalance conditions this vibration has been excited, and the only practical cure was to improve the bearing. Failure of all or part of the bearing surface sometimes results in this type of vibration.

Subharmonic resonance is very often diagnosed as oil-whip, and consequently oil-whip has been thought to have an extra set of properties which of course in reality it does not have. Positive identification of self excited vibration in rotating machines is quite easy with a graphic record of the actual motion, and extremely difficult without one. In the case of subharmonic resonance and oil-whip, positive identification is essential because about opposite steps are required for correction.

Conclusion

Bearings are an essential element in all classes of dynamical machinery, and serve to link parts with relative motion. Very often this primary function is exceeded and vibration properties are manifest which may or may not be desirable. Some of these properties have been discussed in connection with forced and self-excited vibration. It appears that increasing speeds and demands for improved machine performance will require greater attention to the influence of bearings and lubrication on the vibration of machines.

[2] B. L. Newkirk and H. D. Taylor, "Shaft Whipping Due to Oil Action in Journal Bearings," *General Electric Review*, Vol. 28, 1925, pg. 559.

INDUSTRIAL RESEARCH—A NEW SCIENCE

Excerpts from a speech delivered by Dr. C. F. Rassweiler, Vice-President for Research and Development of the Johns-Manville Corp.

It is the common impression that industrial research consists simply of applying the traditional sciences such as chemistry and physics to the solution of industrial problems. This, in fact, however, represents only a portion of the work done by industrial science because with American resourcefulness and ingenuity the scientists in industry have developed entirely new skills and techniques for the solution of industrial problems which cannot be solved by the methods of traditional science. In doing this they have actually created a new science, which might be called "the science of solving practical problems scientifically."

For this science they have borrowed largely from the older sciences, taking from chemistry the conceptions of the relationship between composition and properties, from physics the methods of exact measurements and the respect for quantitative measurement of performance, and from mathematics the technique of organizing and analyzing data. However, in creating this new science they have done more than simply borrow from the old; they have created entirely new skills and techniques.

One of the most important of these is the skill in predicting from small laboratory experiments exactly how a process will operate on a big plant scale and how a product will perform over years of practical service. New products can be released rapidly to improve our standards of living because the industrial scientist can predict in advance how long a paint will resist the weather and how many miles a tire will go before it disintegrates.

It is important that the industrial scientists adhere to the age-old scientific principles — first, the search for causes and the intense desire to know why things happen; second, a determination to accept as fact only those things which can be proven; third, a determination to marshal and study all the facts available; fourth, a respect for the evidence and viewpoint of others; fifth, a willingness to change one's opinion in the face of new evidence; and sixth, a determination not to proceed blindly but to plan and follow a plan toward a definite objective.

We accept the accomplishments of this new industrial science every day without realizing the extent to which they are the result of the efforts of men who have been willing to pioneer away from the traditional paths of the old sciences.

Notes on Heavy-Duty Diesel Engine Bearings

By L. M. TICHVINSKY*

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The author is Professor of Mechanical Engineering at Washington University in St. Louis. He has authored more than 20 scientific papers on bearings and lubrication, and has had a varied experience in industry. Before coming to Washington University, he was Vice President of the American Bearing Corporation and has also conducted research at the Westinghouse Research Laboratories and at the U. S. Naval Engineering Experiment Station. Professor Tichvinsky received the degree of Diplom Engineer at the Prague Polytechnic Institute in Czechoslovakia, 1929.

Introduction

THE design of heavy-duty Diesel engine bearings requires thorough knowledge and understanding of a number of fundamentals. First, the type of cyclic loading which depends on the forces caused by the varying gas pressure and the dynamics of the crank mechanism. Secondly, physical properties of bearing materials such as linings and backing metals and properties of lubricating oils. Thirdly, overall conditions of operation and engine maintenance.

Engineers have accumulated a great deal of valuable and new information because of extra-severe duty to which some of the Diesel engines were exposed during the war. This is especially true with respect to bearing materials, lubricating oils, operation and maintenance. New methods have been introduced to build sound bearings, which will operate at high loads longer than before. New oils, containing additives, with such characteristics as detergency, anti-oxydation and anti-foaming, have been successfully used. Marked improvement in operation and maintenance resulted due to new, carefully prepared specifications.

This article deals with but a few new ideas which were incorporated to improve the performance of heavily loaded bearings, installed in both, Marine and land-type Diesel engines.

Performance of Power Bearings

The performance of bearings which are not subject to dynamical loading is rather simple. The best example of such a bearing is one used in power machinery such as turbines, generators, motors, gears and others. All these bearings are characterized by a rather large vertical force, produced by the weight of the rotating mass, and by a more or less continuous side force, which is due to additional load depending on the type of machinery. Examples of power bearings are shown on Figure 1. It is seen that the loading of such a bearing is simple, there being only two forces, one, F_w, which is due to the weight of the rotating masses, and the other, F_1, which is due to a lateral force such as steam reaction force or a force resulting from the intensity of tooth pressure. The resultant force, F_{res}, acting on a bearing is obtained by the summation of these two forces by the rule of the parallelogram. It can be seen that if the rotation is reversed the resultant force will act as shown by the broken line. It is important to realize that, as is the case in almost all power bearings, the resultant bearing force may span only a limited arc of the lower-shell circumference. In general, there are no forces, which act on the upper shell (if they are, they are small in comparison with the vertical force). For this reason the clearance of the upper shell is usually considerably larger than the clearance of the lower shell. All power bearings, as a rule, are provided with side reliefs which serve as lubricating oil reservoirs from which the oil is dragged by the rotating journal into the load carrying bearing clearance. Power bearings may be designed with 30 or 45-degrees reliefs, in some cases they are entirely omitted; accordingly such bearings are defined as 120, 90 and 180-degree bearings. In case of high elevation of the side force vector, the split line is inclined, as in some gear bearings, Fig. 1. Forced-feed lubrication is not always employed in these bearings. Existing practice indicates that standard oil-ring bearings can perform adequately up to journal speeds of slightly below 2,000 feet per minute. Grooved oil rings have been already applied with success to high-speed rotating machinery.[1] *) In general, these bearings are not heavily loaded and in most cases design pressures are selected which range from 100 to 150 psi on the projected area. An exception from these general pressure limits is the Kingsbury-type thrust bearing which carries very high loads; in these bearings pressures of 350 to 400 psi are common, and pressures of approximately 500 psi may be used. Test pressure of 800 psi have been previously reported.[2])

Power bearings as a rule seldom run hot; in most cases the maximum temperature does not exceed 180-200 degrees Fahrenheit. Heat dissipation from the bear-

* Member A.S.L.E. Paper presented at 3rd Annual Convention of A.S.L.E. April 19-21, 1948, Buffalo, N. Y.

* Number in parenthesis refers to the bibliography at the end of the article.

ing surface of power bearings, such as used in electric industry, was found to equal .008 watt per square inch per degree Centigrade rise in quiet air and 0.02 watt per square inch per degree Centigrade in a draft at approximately 500 feet per minute air velocity (these figures should be divided by 0.0037 for conversion into BTU per hour per square foot per degree Fahrenheit), [3].

Power bearings especially of large sizes are equipped with adequate oil cooling systems which consist of heat exchangers of various types and designs. Oil filters, centrifuges and any similar equipment is usually connected in series with the heat exchanger, thus forming an uninterrupted oil-circulating system.

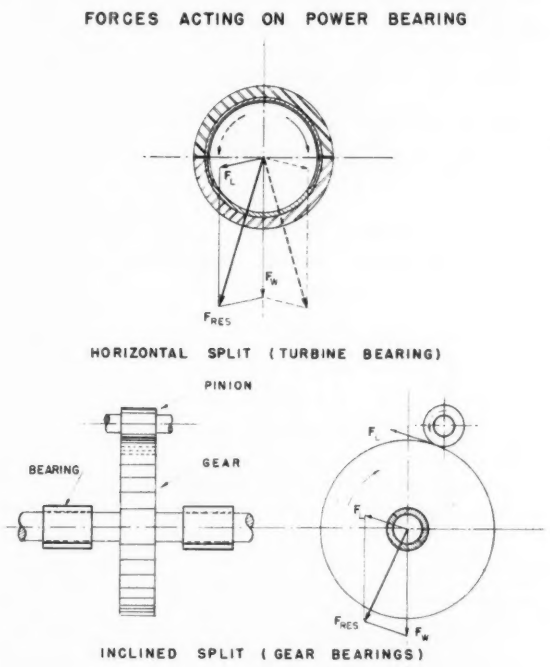


Fig. 1

Performance of Dynamically Loaded Bearings

A. General.

Main bearings, especially connecting-rod bearings installed in aviation and automotive and Diesel engines operate under heavy-duty conditions. The loading of all these bearings is of the same character, the difference being in the intensity which depends on rotational speeds and bearing size limitations. As an example, Fig. 2 shows the relationship between all forces acting on Diesel engine bearings. There are three forces acting on the connecting-rod bearing:

Force due to gas pressure ..... F_p
Force due to the inertia of the reciprocating masses ..... F_{rec}
Force due to the rotation of the masses of the rotating weights ..... F_{cen}

The first of these forces is called gas force, the second, the inertia force, and the third, the centrifugal force. Expression for the evaluation of these forces are on Fig. 2. Vector representation is indicated for one position of the crank angle, namely for 45 degrees.

The relationship of the forces acting on the main bearing is also shown on Fig. 2. For the main bearing there will be two forces, one of which, the centrifugal, is acting along the crank center-line and is due to the mass of the big end of the connecting-rod together with the unbalanced part of the crank, and another, which depends on the magnitude and direction of crank-pin resultant force.

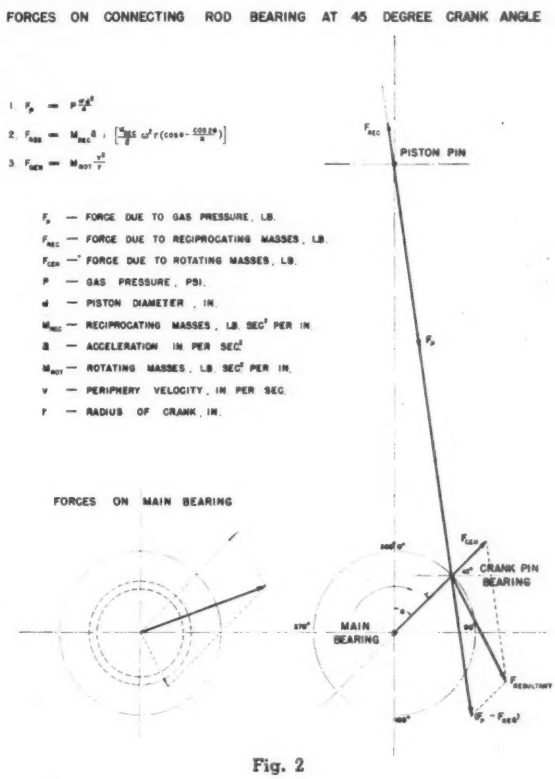

FORCES ON CONNECTING ROD BEARING AT 45 DEGREE CRANK ANGLE
1. $F_p = P\frac{\pi d^2}{4}$
2. $F_{RRS} = M_{REC}\,\beta = \left[\frac{W_{RS}}{g}\,\omega^2 r(\cos\alpha + \frac{\cos 2\alpha}{n})\right]$
3. $F_{CEN} = M_{ROT}\frac{v^2}{r}$
F_p — FORCE DUE TO GAS PRESSURE, LB.
F_{REC} — FORCE DUE TO RECIPROCATING MASSES, LB.
F_{CEN} — FORCE DUE TO ROTATING MASSES, LB.
P — GAS PRESSURE, PSI.
d — PISTON DIAMETER, IN.
M_{REC} — RECIPROCATING MASSES, LB. SEC^2 PER IN.
β — ACCELERATION IN PER SEC^2
M_{ROT} — ROTATING MASSES, LB. SEC^2 PER IN.
v — PERIPHERY VELOCITY, IN PER SEC.
r — RADIUS OF CRANK, IN.
PISTON PIN
F_{REC}
F_p
FORCES ON MAIN BEARING
F_{CEN}
CRANK PIN BEARING
MAIN BEARING
$F_{RESULTANT}$

Fig. 2

The inter-relation of all these forces is of prime importance for the evaluation of the connecting-rod and main bearing loads. At the present time, the operation of bearings is analytically determined during the initial stages of engine design. Taking the case of a Diesel engine, it is evident that the gas force depends on the compression ratio, and of course, on the position of the piston; it reaches its maximum value near the end of the compression and at the beginning of the expansion strokes, usually a few degrees past the top dead center. This force acts downward and is directly transmitted by the connecting-rod to its bearing (the force along the connecting-rod is equal to the gas force acting downward divided by the cosine of the angle formed by the vertical and the connecting-rod center line). The inertia force is equal to the mass of the reciprocating parts times the acceleration, therefore, this force depends on the speed of rotation, position of the crank and on the l/r ratio; it is largest when the piston speed is zero, i.e., at the top and at the bottom dead centers. At the beginning of the power stroke, the inertia force is acting opposite the gas force, then it gradually diminishes and slightly before half of the stroke it changes sign and acts in the same direction as the gas force, increasing numerically toward the bottom dead center. For the 45-degree crank angle this relationship is indicated on Fig. 2 where the difference between these forces (F_p minus F_{rec}) is shown as acting at the center of the crank pin. The mass of the reciprocating parts is composed of the weights of the piston, piston pin and bushing and 1/3

of the connecting-rod weight. The centrifugal forces are equal to the mass of the rotating parts times the angular acceleration and are, therefore, different for the main and connecting-rod bearings. They depend on the weights of the crank, the connecting-rod bearing shells and ⅔ of the connecting-rod weight. The centrifugal force acts radially along the crank-shaft crank and is constant for a given engine speed. It is evident from Fig. 2 that the resultant connecting-rod bearing force will be obtained by geometrical summation of the centrifugal force, as one component, with the sum of the gas and inertia forces, as the other component. The resultant force so obtained is defined as to its magnitude and direction, besides, the position of the crank angle at these conditions is also known (45 degrees for the case shown on Fig. 2). The procedure of so evaluating the connecting-rod bearing resultant force is repeated for all positions of the crank at intervals of 10 or 15 degrees. One revolution is considered for a two-cycle engine and two revolutions for a four-cycle engine. If the resultant forces so obtained were indicated as vectors acting at the bearing center, and if their end points were connected, a polar diagram of the bearing loads will be obtained.

Such polar diagrams indicate at a glance the magnitude of the load at any position of the upper or lower bearing half, and the respective crank angle. The polar diagram enables one to figure the bearing peak force, or forces if there are few high points, and to see at what circumferential part of the bearing they act. From the above discussion it is evident that maximum loads for a two-cycle engine will be acting on the upper connecting-rod shell and on the lower main bearing shell. Main bearing loads for 45-degree crank angle are also shown on Fig. 2.

It is interesting to note, this may be easily understood by following the procedure of constructing polar diagrams, that a decrease in engine speed might increase bearing loads. And, indeed, if the gas force remains unchanged and an inertia force of smaller value than before will be subtracted from it the result will be larger than before.

B. Polar Diagrams.

From the foregoing it is realized that each point on the polar diagram is obtained as the summation of the three main forces acting on the bearing. This is true for the cases of the connecting-rod and main bearings; however, for the case of a piston-pin bearing there are two forces only to consider: the gas and the inertia forces. The construction of polar diagrams is rather tedious, especially if one considers that one polar diagram is evaluated for one speed only; for any other speed the calculations have to be made again following, naturally, the same pattern as before. It is interesting to note that the shape of the polar diagram is entirely unpredictable. Even though one might anticipate approximately the general high-loaded areas, the location of the peak loads should be evaluated separately for each bearing at the various operating speeds. In a Diesel Engine the polar diagrams for all piston-pin and connecting-rod bearings are the same but are different for various main bearings. This is due to firing order, crank-shaft design, and number of cylinders.

Polar diagrams for main bearings have rather large horizontal components because of considerable values of the centrifugal force produced by the rotating crank-shaft cheeks, the journal, the connecting-rod bearing and part of the connecting-rod. Polar diagrams for connecting-rod bearings are usually extended vertically because of a comparatively small effect of the centrifugal force of the connecting-rod. Polar diagrams of piston pin bushings have very small horizontal components and are, therefore, markedly extended vertically.

Two typical polar diagrams for a main and a connecting-rod bearings are presented on Fig. 3 and Fig. 4, the former for a double acting and the latter for a single acting, two-cycle Diesel engine, each developing approximately 1600 Hp.

The maximum load of 19,500 lb. acts upward at approximately 45 degrees of the crank angle on the main bearing of the double acting engine, Fig. 3. Since the bearing projected area is 22.5 square inches, the peak pressure is in the neighborhood of 900 psi. The diagram shows also that the high-intensity force acts between 35 and 55 degrees of the crank angle. At the speed of 700 revolutions per minute the duration of the large force is, then approximately 0.048 second. The main bearing of this engine is not heavily loaded. For this reason standard steel-back or bronze-back bearings lined with white-metal alloys or other lining material performed entirely satisfactorily.

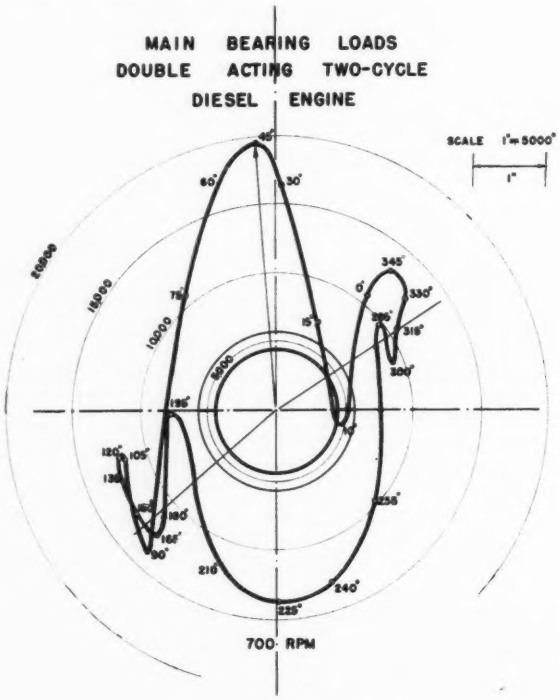


Fig. 3

The maximum load of 50,000 lb. acts downward at approximately 15 degrees of the crank angle on the connecting-rod bearing of the standard two-cycle engine, Fig. 4. Since the bearing projected area is 16.7 square inches, the peak pressure is 2,990 psi. This engine operates at a rated speed of 750 revolutions per minute and large-force intensity prevails between approximately 5 and 25 degrees of the crank angle. As mentioned before, additional loading is possible; thus, full lines on this figure indicate the conditions at the rated speed of 750 revolutions per minute, while dotted lines show the effect of increasing loading which may be produced by lowering the speed of the engine to 600 and to 525 revolutions per minute. The connecting-rod bearing of this engine is heavily loaded. For this reason, the selec-

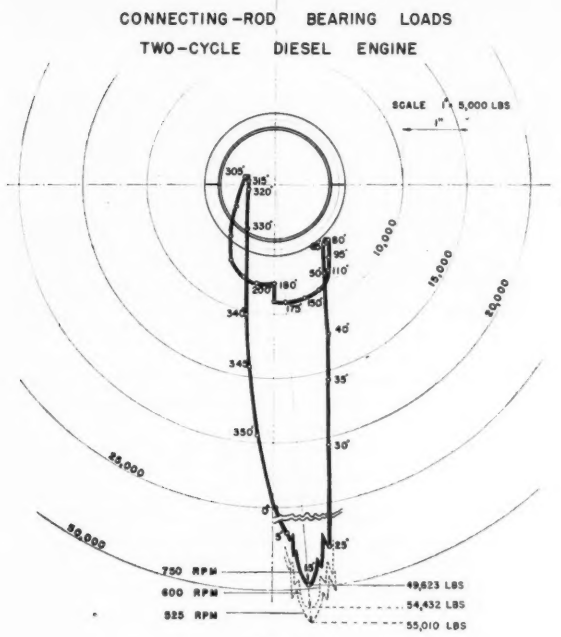


Fig. 4

tion of connecting-rod bearings for this engine requires special attention.

Selection of Bearing Materials

Thus, the study of polar diagrams reveals the severity to which some of the Diesel engine bearings might be exposed. In cases of loads of high magnitude, such as resulting in pressures above 2,000 psi, the design of bearings necessitated extreme care in manufacturing and in selection of adequate materials which could withstand high cyclic loads. Thin white bearing metals, copper-lead, aluminum alloy and grid-type linings have been successfully used in heavy-duty bearings [4], [5].

The backing material of Diesel engine bearings is either steel or bronze, each of which has advantages as well as disadvantages. Steel back bearings possess the necessary rigidity and the bearing linings of all adopted specifications, even of very small thicknesses, may be bonded very securely to the steel back. Grinding of the O.D. of all steel-back bearings is required with the prescribed close tolerances. Bearings with bronze backs centrifugally cast also possess the required rigidity and the bearing linings are also securely bonded to the bronze. However, grinding of the bronze back is not necessary because a smooth finish may be obtained on a turning lathe by proper tooling. Bronze back bearings may be easily stored without danger or corrosion.

The use of centrifugally cast Diesel engine bronze bearing shells is rather new and was logically necessitated by such heavy loads as indicated on the previously discussed polar diagrams, Fig. 3 and especially Fig. 4. Permanent deformation of sand-cast bronze bearing backs due to high peak loads has been previously reported, [5] and [6]. In that case, the upper connecting-rod bearing back was partially extruded into the short and narrow oil slot which was machined in the connecting rod. It was found that such extrusion did not take place with centrifugally cast bronze bearings because of sound, homogeneous and non-porous structure which considerably improved the overall properties of the bronze,[7]). It is known that sand castings may be weak because of segregation and of localized internal porosity which may be revealed by fracture test only.

SPECIFICATIONS OF TWO BEARING-BACK BRONZES

	CU	Sn	Zn	Pb	Fe MAX	Ni MAX	Ph MAX	AL MAX	TENS.STRGTH PSI	ELONGATION %
NAVY M	86-91	63-65	1.5-5	1-2	0.15	1.0	0.05	—	34,000	22
SAE 65	88-90	10-12	0.5*	0.5*	0.15	TR*	.1-.3	.005	35,000	10

* TOTAL LEAD, ZINC, NICKEL 1.0 % MAX ; SAE 65

SUB-SIZE TEST SPECIMEN

SIZE IN INCHES

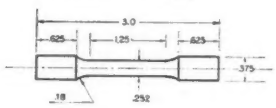


Fig. 5

Centrifugally Cast Bronze Bearing Shells

Most Diesel engine bearings with bronze back are manufactured with the Navy "M" bronze (U.S. Navy 46B8; Federal QQ-B-691a, Comp. 1). Phosphor bronze, such as SAE 65 is sometimes also used. Chemical and physical properties of these two bronzes are tabulated on Fig. 5. Specifications have been prepared, which cover manufacture, and progressive tests, carried at different predetermined stations during the centrifugal casting process.

The hardness of centrifugally cast bronzes for bearing shells should be minimum 55 Brinell (500 kg.) for Navy "M" and minimum 35 Rockwell Number for SAE 65. Different hardness scales are used on account of different characters of the two metals, one, the SAE 65, being a solid solution, and the other, the Navy "M", an alloy where lead might be partially segregated.

Centrifugal castings may be spun on vertical, horizontal and inclined castings machines, [8]). A casting for usually one bearing shell (for two bearing halves), can be obtained on a vertical machine, while a casting for several bearing shells may be obtained on a horizontal machine. The length, or the height, of a casting spun on an inclined machine is limited, and as on a vertical machine, usually one bearing shell is obtained. The speed of these machines may be adjusted in accordance with the magnitude of the centrifugal force desired. On the vertical machine the speed adjustment is effected by means of interchangeable sets of pulleys, and on the horizontal machine — by means of a variable-speed motor. Such and similar centrifugal casting machines were used successfully for manufacturing large number of castings varying in sizes from, approximately 4 in. on the outside to, approximately, 12 in. on the outside.

A good and sound casting is obtained when such variables as spinning speeds, casting temperatures, rate of pour and type of dies are properly determined. In addition, experience may indicate the desirability of different methods in line with personal casting experience which may vary considerably.

Typical molds or dies for centrifugally casting bronze bearing shells may be of the type, as shown on Fig. 6. Dies for vertical machines are made of suitable steel or cast alloy materials; the molten bronze is poured vertically and is held in the mold by a cover. Sometimes, permanent carbon molds are used in horizontal machines which are inserted into the spinning tube; the molten

HORIZONTAL & VERTICAL MOLDS USED FOR CASTING CENTRIFUGALLY BRONZE BEARING SHELLS

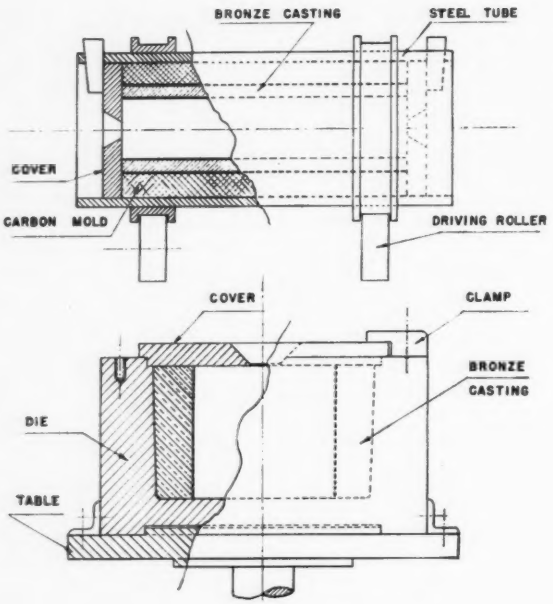


Fig. 6

TEST OF A CENTRIFUGALLY CAST BRONZE BEARING SHELL

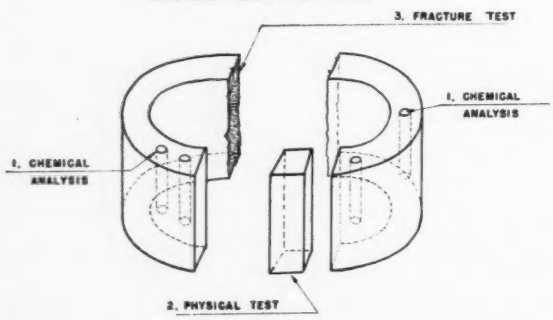
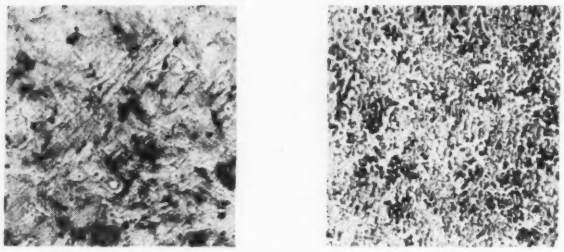


Fig. 7

brass is held by two side covers provided with orifices for side pouring.

The required periodical tests of the bronze castings may consist of visual examination of a fracture, Fig. 7, to indicate if proper methods are used to obtain sould metal. Thus, the fracture examination may indicate such easily detectible defects as axial stratafication, it may be due to low pouring rate, coarse structure which may be due to improper pouring temperature, porosity on the inside diameter area reaching too far radially, it may be due to excess of spray used to cover the die prior to pouring, and radial gas holes, which also may be caused by excess spray. Negative results of such test at once necessitate rectification. All castings which revealed positive fracture tests are tested for chemical composition and for physical properties. A section for the physical test is usually cut from the casting which has been selected for the fracture test. The fracture test is then made, and if positive, chips are secured for chemical tests, see Fig. 7.

Structures of Sand-Cast and Centrifugally-Cast Navy-M Bronze



X100 Sand-Cast

X100 Centrifugally-Cast

Fig. 8

Since many centrifugal castings are short, sub-size test specimens are used for the determination of the tensile strength and the elongation, Fig. 5.* It has been shown, that for the case of the Navy "M" bronze, the tensile strength of a centrifugal casting was 17.7% above that of the sand casting, similarly, the per cent of elongation increase amounted to 54%, [7]).

In general, it can be stated that the physical properties of centrifugally cast bearing bronze shells are greater than those of sand cast bronze of the same chemical composition. Photomicrographs of sections cut through several bronze backed bearings almost invariably indicate that the structure of centrifugally cast materials is sounder than those of sand cast materials, Fig. 8. In the case of Navy "M" structures, Fig. 8, it is seen that in the centrifugally cast material there are no apparent lead segregation, as can be seen in the sand cast material; this is due to the controlled rapid solidification which is an integral part of the centrifugal process.

Conclusion

Some of the Diesel engine bearings may be subjected to severe cyclic loading which result in connecting-rod bearing pressure in excess of 3,000 psi. It is shown that bronze-back bearings for such duties may be used successfully provided the bronze bearing material is cast centrifugally. Because of fine grain and homogeneous structure obtained by centrifugal casting methods physical properties of bronze centrifugal castings are superior to those of sand-cast materials.

Acknowledgment

Acknowledgmend is due to Mr. J. F. Klement, Chief Metallurgist, Ampco Metal, Inc., Milwaukee, Wis., who prepared the photomicrographs shown on Figure 8. The interest in the preparation and presentation of the paper by A. S. Langsdorf, Dean of the School of Engineering, Washington University, is appreciated. Graphs and sketches were prepared by Mr. Tao Kwang-yeh, a Graduate Student.

BIBLIOGRAPHY ON PAGE 190

* General Specifications for Inspection of Material Appendix II, Metals, Part A. Issued by the Navy Department June 1, 1941.

Improved Engine Lubrication Through Used Oil Analysis

By H. L. HEMMINGWAY*

Technical Service Department, The Pure Oil Company

THERE was a time when many of us were convinced that the used oil analysis had little or no relationship to engine cleanliness. Those of you who have had considerable test engine experience have probably seen bad used oils drained from engines which were quite clean and good used oils drained from engines which were quite dirty. There is a considerable difference, however, between the usual laboratory engine tests and typical engine operation in field service; there is ample evidence that much of the dirtiness encountered in field operation stems from a different source than the dirtiness of laboratory engines. It is on this basis that the Pure Oil Company Research and Development Laboratories have been able to develop a method of used oil inspection which appears to have considerable significance in determining internal engine condition.

Actually, only two things happen to oil during use in the engine, as follows:

1. The oil itself may deteriorate, primarily as a result of oxidation. Some of this deterioration may take place and show up in the bulk oil in the sump; or, some of it may take place in thin films of oil on hot parts of the engine, such as pistons, rings, valve stems, etc.
2. The oil may become contaminated with fuel dilution, water, soot, lead compounds, metal particles, dirt, anti-freeze, etc.

In laboratory engines, contamination is usually kept at a minimum, with the primary variable being the deterioration of the oil itself. In engines in actual field service, it is generally agreed that oil contamination is more of a factor than oil deterioration, and facts presented later in this paper substantiate this view.

It is, of course, obvious that oil deterioration and its influence on engine condition is controlled by and is the responsibility of the oil refiner. It is equally obvious that the contributing factors in oil contamination are fuel characteristics, engine design, type of operation, and engine maintenance. Through the years, there have been definite trends of emphasis on oil contamination as influenced by design or maintenance or on oil deterioration as influenced by lubricating oil properties *and* engine design. For example, during the years 1925 through 1935, some 28 papers on oil *contamination* and one paper on high temperature oil *deterioration* were published in the S.A.E. Transactions. That was the era when fuel dilution figures of 10% to 20% were not uncommon, moisture contamination was high, crankcase temperatures were low and air cleaners, oil filters, or effective crankcase ventilation systems were not yet generally used. Most of these papers dealt with the causes and effects of fuel dilution or moisture contamination.

From 1936 through 1946, on the other hand, there were *only 2 papers* on oil *contamination* as compared with *about 49 papers* on oil *deterioration*. Air cleaners and oil filters were becoming standard equipment, and engine designers had disposed of fuel dilution by increasing the oil temperature. At these increased oil temperatures oil deterioration became an important factor.

During the war, detergent type oils having high resistance to oxidation were developed by the oil industry. "Premium" oils were designated by the A.P.I. as oils having special qualities to resist oxidation and bearing corrosion. Today, premium and heavy duty oils are so resistant to oxidation that used oil samples seldom show evidence of any appreciable degree of bulk oil oxidation. As a result, contamination again becomes the predominant factor, and in 1947 through the first quarter of 1948 there have been published in the S.A.E. Transactions some nine papers on contamination as opposed to only four on oil deterioration.

The Four Factors Which Are Vital to Good Engine Condition

1. Engine Design
2. Type of Operation
3. Maintenance
4. Fuel and Oil Quality

If all four factors are "right," a good engine condition will result. If only one factor is neglected, the operation will suffer. No one factor can compensate for a failing in another; if the maintenance is bad, no oil, however good, can compensate for it.

If, when we assume the responsibility for lubricating a new and unknown fleet, the engine could talk, it might tell us whether its design was right for the job it was doing, whether the type of operation suited its capabilities or whether it was too cold all winter or too hot in summer, whether it was properly maintained, and what its preference was as to type and grade of fuel and oil. After the engine was an established consumer of our fuel or oil, if it could talk, it could tell us whether the diet we had prescribed was the proper one, whether it was being fed often enough or too much, or whether its maintenance and operational environment agreed with it.

Unfortunately the engine can't talk, but it is still important for us to know the things it might tell us. One way to find out is to check periodic oil samples. The tests we make on these samples must be tests which will reveal whether or not a desirable engine condition is being maintained. Perhaps we should first, then, define a desirable engine condition:

1. *Wear and friction must be kept at a minimum.* The oil must be dirt-free. Water contamination must be avoided. Metal particles in the oil will reveal that wear is occurring. The oil must not be too thin to protect rubbing surfaces, or too thick to resist circulation when cold.

   Thus, to prevent wear, we must be able to detect in the oil the presence of dirt, moisture, and metal, and also any significant changes in oil viscosity.
2. *The engine must start readily at low temperature.* This means that compression, carburetion, and igni-

* Member A.S.L.E. Presented before the Chicago Section of A.S.L.E., March, 1948.

tion must be right, and the oil must not be too heavy. Since poor compression, carburetion, or ignition contribute to incomplete burning of the fuel—resulting in the formation of soot, fuel dilution, and other blowby products—the used oil analysis must be able to detect the presence of these materials in the used oil. The viscosity measurement is significant in determining the influence of the oil on starting.

3. *A good engine condition is typified by good fuel and oil economy.* Here again the viscosity of the oil is important in maintaining low oil consumption, and the presence of soot, dilution, or other blowby products in the oil is an indication of engine conditions leading to poor fuel economy.
4. *The engine should remain clean.* Engine cleanliness is affected by oil deterioration and contamination. In the used oil test we should be able to detect the beginning of oil deterioration and to differentiate between deterioration or oxidation of the oil and contamination. The presence of contaminants will lead to engine dirtiness, so the used oil test must detect them and, if possible, provide a clue as to source. The used oil test should also indicate whether or not detergent-dispersant type additives are still effective or have worn out.

Since all oxidation is usually characterized by viscosity increase and/or the formation of insoluble sludges, our test method must be able to detect and identify these contaminants:

Oil Contaminants

Soot	Metals	Dirt
Lead Salts	Fuel Dilution	Anti-Freeze
Water	Fuel Gums	Materials Added Through Sabotage

Test Methods

The following used oil test method was a development of Dr. L. M. Henderson, and Messrs. R. J. Askevold and Richard Rue, working under the direction of Mr. W. B. Ross, Manager, The Pure Oil Research and Development Laboratories. It was developed to meet the following requirements:

1. *Speed.* Twenty-four hour test results were requested. Actually, when running to capacity, the time per sample is about 21 minutes.
2. *Reasonable Accuracy.* Extremely accurate results are not required in used oil testing since the oil is continually changing in properties anyway, and usually we are more interested in a trend than in absolute values. Accuracy and reproducibility of plus or minus 10% was specified. Actually, the tests are running closer to plus or minus 5%.
3. *Minimum Expense.* Streamlining and mass production techniques, involving as much automatic instrumentation as possible, were specified, in order that considerably less skilled operators than those required for the usual A.S.T.M. procedures could be employed.
4. *Significance.* The significance of the results should be comparable to the significance of A.S.T.M. used oil tests, or special tests used by some commercial laboratories.

All of these objectives were realized in the test procedure described below:

Viscosity. The importance of viscosity measurement is well known, and the apparatus used is shown in Figure 1. A portion of the sample is placed in an oven for preheating to test temperature (100°F) upon receipt. Later it is transferred to one of the 16 beakers suspended in an oil bath from the turntable shown in Figure 1. The viscosimeter is the device shown at the right in the operator's hand. An electric motor in the head drives a spindle equipped with a calibrated disk. The dial registers motor torque at synchronous speed, which can be converted to viscosity. Total time required for filling the beakers, measuring torque, washing torque shaft between measurements, converting torque measurements to viscosities, emptying beakers and washing in preparation for next test is about 110 minutes for 16 samples, or around 7 minutes per sample.

The author received his Bachelor's degree in Electrical Engineering and Master's degree in Mechanical Engineering from the University of Wisconsin. He has been associated with the petroleum industry since 1933. During the war, Mr. Hemmingway was a member of various technical committees on oils, gear lubricants and greases of the S.A.E., N.L.G.I., N.P.A. and the A.P.I. He is now Assistant Manager, Technical Service Department, of the Pure Oil Company.

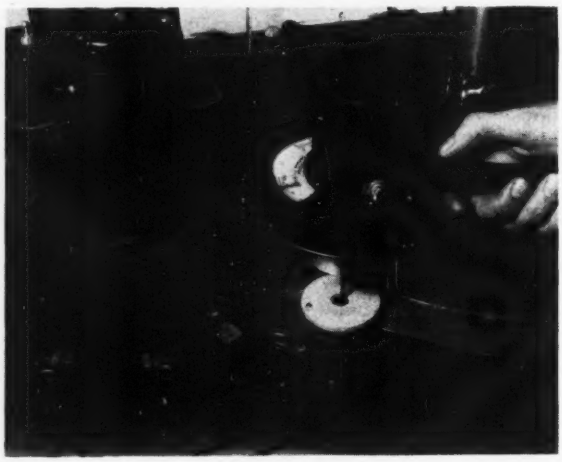


Fig. 1

Fuel Dilution and Water. Fuel dilution and water are measured in automatic vacuum stills. A battery of six are available, and, after the flasks are filled with a measured quantity of used oil, the remainder of the operation is more or less automatic. Vacuum is applied and maintained, and heating of the flask takes place at a predetermined rate, both under automatic control. Heating stops automatically at the temperature where previous tests have indicated that all raw fuel and water are evaporated. The relative quantities of each can be observed in the trap.

Percentage of Solids. Percentage of solids is observed volumetrically after dilution with special naphtha, and centrifuging. The first centrifuging determines "undispersed" solids. With detergent oils, however, the dispersed solids cannot be separated by simple centrifuging. Therefore, following the first test the diluted sample is treated with a flocculating agent, and is whirled again. All of the solids come down in the second test, and are recorded as "Total Solids." By difference, the "Dispersed Solids" are determined. This test if of great value in determining the effectiveness of the detergent and also the condition of the oil filter.

Following the determination of total solids, the special naphtha diluent is decanted and a second solvent added. This solvent is more or less specific for high molecular weight decomposition products resulting from oil decomposition. That portion of solids which is dissolved by this solvent is recorded as "Tar and Asphaltic" material. A third solvent, more or less specific for lower molecular weight fuel decomposition products, is now added and the amount dissolved is recorded as "Gums."

The remaining material—consisting of soot, carbon, lead compounds, dirt, metal particles, etc.—is listed as "Insolubles."

Types of Insolubles. To determine types of insolubles, the insolubles are removed from the tube and spread on a microscope slide, and examined under a microscope. This simple examination has been surprisingly effective in detecting abnormal amounts of solid contaminants which, as indicated by subsequent examination of the engines, were beginning to cause damage.

Significance of Tests

Following are examples of typical test results picked at random:

SAMPLE	A	B	C	D	E	F
Type Service	CITY BUS	RENTAL CAR	OVER THE ROAD TRUCK	BUS	BUS	WELL PUMPING
Total Engine Service	23,375 mi.	18,000 mi.	26,237 mi.	26,043 mi.	10,274 mi.	36,920 hr.
Type Fuel	Reg. Gaso.	Reg. Gaso.	Reg. Gaso.	Reg. Gaso.	Reg. Gaso.	Nat. Gas
Type Oil	H.D.	Prem.	H.D.	H.D.	H.D.	H.D.
Oil Miles or Hours	1600 mi.	1000 mi.	1000 mi.	3000 mi.	3397 mi.	336 hr.
Oil Filter Type	Waste	None	None	Waste	Waste	Waste
Filter Miles or Hours	1600 mi.	———	———	3000 mi.	3397 mi.	336 hr.
Viscosity Change	Down 42%	None	None	Down 67%	Down 20%	None
Total Solids, Per Cent	**2.4**	**15.0**	**4.6**	**2.3**	0.0	0.2
Undispersed Solids, Per Cent	**2.4**	**13.0**	0.0	0.0	0.0	0.0
Dispersed Solids, Per Cent	0.0	2.0	**4.6**	**2.3**	0.0	0.2
Tar and Asphaltic, Per Cent	0.1	**4.0**	**1.8**	0.3	0.0	0.0
Gums, Per Cent	**2.0**	9.8	**1.1**	0.6	0.0	0.0
Insolubles, Per Cent	0.3	**1.2**	**1.7**	**1.4**	0.0	0.2
Water, Per cent	0.0	**2.6**	0.0	0.0	0.0	0.0
Fuel Dilution, Per Cent	**6.4**	**5.8**	3.3	**13.6**	3.8	0.0
Soot	Sl.	Ex.	Ex.	Sl.	N	N
Grit	N	Ex.	Ex.	N	N	N
Metal	Ex.	Ex.[a]	Ex.	N	N	N

a.—Large amount iron and bearing metal present.
N—Negligible or normal amount present in sample.
Sl.—Slightly higher than normal amount present.
Ex.—Excessive amount present in sample—immediate correction indicated.
Figures in bold face type indicate abnormal condition—immediate correction indicated.

Sample A is from a City Bus. The amount of fuel dilution is high for this service, and viscosity has been reduced over 40%. The amount of solid material is excessive for operation with a good oil filter, and the detergent is no longer effective in dispersing the solids. The solid materials appear to be mostly fuel soot and fuel gums. An excessive amount of metal indicates rapid wear.

The diagnosis here is quite obvious. Engine tune-up is required. Compression, ignition and carburetion should be checked, and engine operating temperatures may be too low or crankcase ventilation inadequate. The rapid wear may be a result of excessive dilution or too low oil temperature.

Sample B is an extreme example of a bad oil condition. Solids are excessive and both fuel and oil deterioration products are present. Fuel dilution is high, excessive moisture is present, and excessive amounts of soot, grit, and metal were detected. In this case a complete engine overhaul was recommended, with special attention to sources of water leaks, and more careful maintenance of air cleaners in future.

Sample C from an over-the-road truck is dirty, contains both fuel and oil deterioration products, and abnormal amounts of metal and dirt. Failure to maintain air cleaners had caused excessive wear and extreme blowby, with resultant contamination and deterioration of crankcase oil.

Samples D and E were drained from buses of the same make, operated by one fleet in a combination of city bus and cross country service. Sample E obviously is in excellent condition, while sample D is dirty, and shows excessive fuel dilution and soot. All of the variations between the buses that produced this difference are not yet known; it is known, however, that Bus D was operated at very low crankcase temperatures due partly to overcooling of the cooling liquid, and it probably was less carefully tuned and had less adequate crankcase ventilation than Bus E. It is noteworthy that engines showing good oil tests in this fleet were satisfactorily clean, while those showing unsatisfactory oil condition were dirty.

Sample E is from a four cylinder power unit operating on natural gas in oil well pumping service, and operated by the Pure Oil Company Producing Division. It is included here to show the excellent oil condition which results from the use of an engine properly *designed* for this *operating condition,* with the *proper quality fuels and lubricants* and *good maintenance.* Where all of these four familiar factors are right, the oil and engine condition is always satisfactory. These engines operate 24 hours a day, seven days a week, and

(*Continued on page* 191)

CURRENT LITERATURE

LUBRICATION ENGINEERING is starting with this issue to present brief abstracts of pertinent literature covering lubrication and related fields. The abstracts are obtained from a variety of sources, with the greater portion of this particular list being furnished through the courtesy of Dr. C. M. Larson.

Chemistry & Engineering, No. 7, February 14, 1948

GERMAN PETROLEUM AND SYNTHETIC OIL

Anon.—p. 98

In the Report on the Petroleum and Synthetic Oil Industry of Germany (1947), by a Mission from the Ministry of Fuel and Power, is given the result of an investigation of the manufacture in Germany of products from coal and petroleum for use as fuels and lubricants. The report is divided into seven sections: (1) Carbonization and Gasification of Coal; (2) Hydrogenation Processes; (3) Fischer-Tropsch Process; (4) Crude Oil Production; (5) Petroleum Refining; (6) Lubricating Oil Production. and (7) Testing and Evaluation of Products. The data of the report are reviewed.

A NEW PROCESS FOR THE RECOVERY OF ETHYLENE FROM COKE OVEN GAS

Schuftan, P. M.—pp. 99-104

The paper was read at a joint meeting of the Chemical Engineering Group with the Low Temperature Group of the Physical Society, November 18, 1947. The new process described here produces ethylene of 97% or more directly from coke-oven gas and as the main product. The process was developed by the British Oxygen Company and the large experimental plant was built at Corby. The principle of the process is explained and a simplified flow diagram is given. The plant is described and the results and prospects are discussed. Forty-five references are given.

Chemical Engineering, Vol. LV, No. 2, February, 1948

SYNTHETIC ORGANIC CHEMICALS

Anon.—pp. 110-111

A graph shows the pattern of the synthetic organic chemicals industry as seen in the growth chart of its two great branches. Since the acyclics came out of nowhere in the middle 20's, the cyclics have had difficulties keeping pace. Table 1 shows production of certain synthetic organics in the United States for 1939, 1943, 1944, 1945 and 1946. Table 2 shows production of certain cyclic synthetics for the same years.

PETROCHEMICALS

Anon.—pp. 112-113

Announced construction plans and construction actually begun during the last 12 months shows that 1948 will witness an unparalleled production of chemical intermediates and finished chemical products from petroleum and natural gas from the Southwest. Many new products with potentialities have emerged. Scheduled for 1949 or 1950 completion are the plants of Stanolind Oil & Gas Co. in the Hugoton Field in Kansas and Carthage Hydrocol near Brownsville, Texas, for production of synthetic gasoline and byproduct chemicals by catalytically synthetising carbon monoxide and hydrogen by processes for superior to the original Fischer-Tropsch method.

COAL CHEMICALS

Anon.—p. 115

Coal chemicals were produced in 1947 at near capacity rates. A graph shows the picture from 1919-1949. Refining of primary coal products by oven operating companies has increased substantially during the war. A large percentage of total production is refined and substantially wider variety of products is made. Pyridine chemicals have received increased attention because of critical demand.

PLASTICS AND SYNTHETIC RESINS

Anon.—p. 116

Although thermosetting plastics continued their steady growth in 1947, the thermoplastics end of the industry suffered difficulties early in the year. The slump in demand could be attributed partly to bringing in new production capacity and reduction of high inventory stocks. This situation eased in the fall and by the end of the year sales were at record heights. New resins have been introduced and new uses found. Perhaps the vinyl chloride group is one of the most important. Polyvinylchloride may be blended with GR-N synthetic rubber, the copolymer of acrylonitrile and butadiene. The Resinous Products and Chemical Co. produced two new plastics, Uformite F-240, a butylated urea-formaldehyde and Duraplex ND-78, a non-oxidizing phthalic alkyd resin.

PETROLEUM REFINING

Anon.—p. 119

The problem of expanding capacity of existing equipment to meet an unprecedented demand for petroleum products has been paramount. New design of equipment for successful operation of catalytic cracking units of small capacity dispelled a supposition of a few years ago that such units could not be built. Material increases in refining capacity also resulted from redesign of existing equipment to remove bottlenecks. Restoration of idle capacity to use was another factor in enabling the refining industry to meet the heavy demands. Efforts to reduce manufacturing costs have occupied all refiners. Many millions of dollars have been spent on research but no accurate, reliable estimate of the exact amount to be spent in 1948 is available.

OILS AND FATS

Anon.—pp. 124-125

Increased domestic production for imports of fats and oils gave process industries a little more flexibility than they had since the war began. Solvent processes are taken up. Some statistics are presented. Production of about two billion pounds of tallow and grease in 1947 set the record. Figures for cottonseed products in 1946 and 1947 are given. Peanut oil production in the year ending August 31, 1942, was second only to the 1941 record of 174 million pounds. Coconut oil availability in 1947 was high. Flaxseed production in 1947 in the United States was about 40 million bushels. Tung oil production was about 12.7 million pounds.

FATTY ACID DISTILLATION

Anon.—pp. 146-149

Fatty acids can be purified and separated by distilling operations. Wilson & Co. is using bulk overhead distillation at its Philadelphia works to produce fatty acid blends, while Armour & Co. has installed a fractional distillation system at Chicago. Foster-Wheeler designed both systems. A flow diagram of each system is presented.

TETRAETHYL PYROPHOSPHATE

Anon.—pp. 176, 178

The German developed insecticide discussed here consists of tetraethyl pyrophosphate. Nifos-T contains 40% of this according to the manufacturer, Monsanto Chemical Co. In conjunction with DDT as a dust or spray, this compound will destroy mites and aphids that multiply abnormally after extinction by DDT of their natural insecticide enemies.

AROMATIC CHEMICALS FROM PETROLEUM

Parkhurst, G. L.—pp. 266, 268
(Oronite Chemical Co., before Pacific Industrial Conferences, San Francisco, Oct. 23, 1947)

At the close of the second World War, toluene demand dropped as it did at the close of the first World War. The postwar benzene picture is different and demand did not drop off sharply. It is safe to predict that the chemical uses for it will increase rapidly. Xylenes are already being produced from petroleum. Higher aromatics have not so far been produced commercially by the petroleum industry in a high state of purity. Cresylic acids have for some years been produced from petroleum and are competitive with those of coal tar. However, their production has been of a byproduct type and so can not be greatly expanded. Synthetic organic detergents have long been made by numerous companies.

HOW TO FORM A CORPORATE PATENT POLICY

Davis, A. S., Jr.—pp. 272, 274
(Research Corp., before Industrial Research Inst., Niagara Falls, Ontario, Sept. 25, 1947)

By CORPORATE patent policy is meant the way in which a corporation looks at the patent system and what it wants to make it do for it. It does not refer to the daily detail, patent prosecution or the administrative technique of seeing that inventions are taken over by the patent department from the laboratory. It does not refer to the usual dealings on patent matters nor the forms of agreements companies enter into among themselves. It involves these items but is very much broader as it refers to the general attitude of the company toward patent actions and deals with the "why" rather than the "how" and "what." It refers to the patent policy of the company as a whole.

PETROLEUM RESERVES vs. PETROLEUM CONSUMPTION

Schroeder, W. C.—pp. 274, 276
(U. S. Bureau of Mines, before American Inst. of Chemical Engineers, Detroit, Nov. 13, 1947)

Causes for petroleum shortage in the United States include low rate of discovery and sharp rise in demand. 4 million barrels of oil a day were needed before the war, 5 million barrels a day during the war, and 5½ million barrels at present. Before 1951, it is believed the demand will reach 6 million barrels a day. Some believe imports are the answer, especially in the Persian Gulf area, but it is doubtful that we have any material amount of oil that can be made available from this source for use in the United States before 1951. Secondary recovery methods are gaining importance. Methods have been developed for converting natural gas to motor gasoline. Oil shale offers a source. However, the United States has adequate coal from which oil can be made. Such reserves will be sufficient to last 100 years. The synthetic fuel industry is a large and complicated job and to produce 2 million barrels of oil a day synthetically may require an investment of 8 or 9 million as well as perhaps 15 million tons of steel.

NEW TECHNIQUE REMOVES FISCHER-TROPSCH HEAT

Storch, H. H.—pp. 276, 278
(U. S. Bureau of Mines, before Philadelphia Section, American Chemical Society, October, 1947)

Synthesis of liquid fuel by combining carbon monoxide gas with hydrogen by use of heat and catalysts and sometimes increased pressure is carried out by several companies in the United States. They have done development work on a process utilizing fluidized powder technique. One plant with a capacity output of 8,000 barrels per day was erected at Brownsville, Texas. It will use natural gas. Pilot plant test showed it may operate continuously for as long as 1,600 hours, producing chiefly gasoline with minor amounts of Diesel fuel and chemicals. The Bureau of Mines has developed another technique for removing the tremendous heat generated. An oil goes into the converter with the gas mixture. As the oil touches the hot surface, it evaporates and absorbs heat. This technique permits elimination of bulky expensive cooling equipment and gives excellent control. With this method, the catalyst is spread in pellets in a fixed bed.

COLOMBIAN PETROLEUM

De'leur, J.—p. 282
(Digest from "Notes on the Economic Geology of Colombia," Dyna, No. 57, 1936, 1947 [Published in Columbia]

Colombia fields hold ninth place among the world's petroleum producers and second place in South American countries. The attached table shows quantity of petroleum produced from 1921 through 1945. The low figures for 1942 and 1943 are due to difficulty of maritime transportation during the war. The Tropical Oil Co. and the Colombian Petroleum Co. have the chief concessions in commercial production.

Chemical Engineering, Vol. LV, No. 4, April, 1948

PRODUCTION OF MANUFACTURED GAS USING GAS TURBINE CYCLES

Jenny, F. J.—pp. 108-111

Development of continuous processes for converting coal to gas is one of the important phases in the synthetic fuels research program currently under way in this country. A process has been outlined for the continuous production of manufactured gas from solid and liquid fuels. The process incorporates a gas turbine cycle which generates the power required for the air and oxygen compressors of the oxygen unit, and in addition may also generate by-product power. Consideration is also given to a simple cycle using atmospheric air, again with a gas turbine, and using liquefied petroleum gas for enrichment.

THYSSEN-GALOCSKY, LURGI PROCESSES PROMISING FOR GAS MANUFACTURE

Anon.—p. 121

Two promising gasification processes, Thyssen-Galocsky and Lurgi high pressure, were utilized by the Germans during the war to manufacture gas for Fischer-Tropsch liquid fuel synthesis.

(*Continued on page* 188)

NEW PRODUCTS and EQUIPMENT

NEW BARREL TRUCK

A light-weight, but extremely rugged general purpose hand truck is now available from General Scientific Equipment Company, 27th and Huntingdon Streets, Philadelphia 32, Pa.

According to the manufacturer, the outstanding feature of this hand truck is the two chime hooks, which are adjustable, to lock barrels and kegs of different heights securely in position. Truck is finely balanced so that most of the load is carried on the wheels, thus making it easy to use and handle.

Address General Scientific Equipment Co., 27th and Huntingdon St., Philadelphia, Pa.

HYDRO-SOLV "A"

A new sludge and gum solvent has been developed by the Swan-Finch Oil Corporation for the users of hydraulic equipment. The new product, known as Hydro-Solv "A," can be added to regular hydraulic oils to remedy any sluggish operation caused by contaminants.

After the recommended 100-150 working hours allowed for the treatment, the system should be completely drained and new oil put in. Gum and sludge, either in solution or suspension, is removed with the dirty oil. There is no necessity of cleaning the system after using Hydro-Solv "A." Simply refill and resume production.

Hydro-Solv "A" is a liquid concentrate composed of several highly active organic gum and sludge solvents. These compounds have been specially selected to perform specific functions when added to a used oil in a contaminated system. Final product is a delicate balance and blend of each organic chemical having high compatibility and stability. The product is not a lubricant in itself and consequently can not be used neat in a hydraulic system. The product is non-corrosive and will not affect fine surface finishes.

New literature is available from Swan-Finch on this product.

SOLVENT BOOKLET

The DuBois Company announces the reprinting and supplementing of their booklet on solvents, which was first released several months ago. The initial demand was so great that it is being offered again with additional data.

This booklet contains information on flash points, boiling ranges, chemical constitution, toxicity, trade names, etc., on those solvents most frequently used in metal cleaning. It makes possible easy selection of the correct solvent for a particular job.

This booklet discusses the use of emulsifiable solvents and the fast growing popularity of emulsion cleaning, and the effect of the various solvent groups on particular oils.

Flash points are also given on each of these solvents mixed with Actusol, an emulsifiable oil detergent manufactured by The DuBois Company. Actusol raises the flash of combustible solvents and provides protection for the skin. Actusol is an emulsifiable oil detergent used to augment the solvent power, to emulsify insoluble oils, and to provide water rinsability in solvent cleaning operations.

Requests for this booklet should be sent to The DuBois Company, Cincinnati 3, Ohio.

New Drum Pump

This efficient, self-priming drum Pump for alcohols,, paint thinners, light oils and other volatile liquids is equipped with a positive shut-off valve that is absolute protection against evaporation losses. Its maximum capacity is 15 gallons per minute.

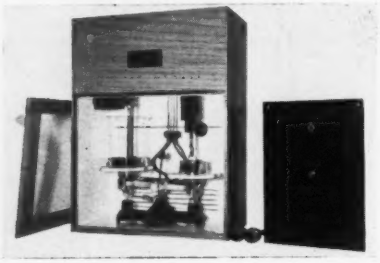
The No. 750 pump has no pistons, rings or leathers; no rotating parts to stick or wear. The special diaphragm is a heavy cord-fabric vulcanized between synthetics. It does not dry out, swell up, rust or corrode and is unaffected by petroleum products, alcohol and most other fluids.

A handy fill-spout makes it easy to fill measuring cans and containers. All waste is prevented by an automatic drain back which completely drains hose and pump when handle is lifted. A locking link, near the middle of the handle, can be used to prevent use of pump by unauthorized persons.

The No. 750 pump, sturdy and trouble-proof, is economically priced at only $10.75. Write for complete data or order direct from the General Scientific Equipment Company, 2700 W. Huntington Street, Philadelphia 32, Pa.

AUTOMATIC LIQUID BALANCE

The flow measurement of any liquid can now be automatically determined *by weight,* by the use of the new ERDCO Automatic Liquid Balance. This device operates without any interruption of the flow. By eliminating the possibility of human error, it obviates the necessity of time-consuming reruns.



This Automatic Liquid Balance operates on the principle of measurement by weight, which has been established for many years as the most accurate method of determining flow of fluids. It advances the use of the weight system by making unnecessary all manual operation of valves, weight lifters, and switches. It measures the time required for a given quantity of liquid to flow, as determined by balancing against a calibrated weight. The determination is therefore independent of the physical properties and temperature of the liquid.

Because the operation is entirely automatic, there is nothing to be done or watched after the switch is turned on, and the operator is completely free to perform other duties during the weighing cycle. Other of the definite advantages over the former methods are: liquid wastage is stopped; there is no carry-over when liquids are changed; there is less fire hazard with inflammable liquids; the complete flexibility offered by different values of weights satisfies various requirements; and the accuracy of the measurement is unquestionably precise.

This Automatic Liquid Balance is equally adaptable to the flow measurement of lubricating oil, coolants, alcohol, acids, or other liquids. It may become a part of regular laboratory equipment for constant use or for special tests, such as the primary calibration of continuous-reading flowmeters.

The weighing section is installed in a polished hardwood cabinet with removable glass door. The cabinet is 24" high, 18" wide, and 9" deep. The remote control unit is in a flush mounting metal box, having a panel size of 9½"x13¾". It may be equipped with an electric stop clock or counter. The ERDCO Automatic Liquid Balance is now available, being produced by the Engineering Research and Development Company of Hinsdale, Illinois.

SUPER-FLUX

The Elliott Chemical Company, Struthers, Ohio, plans national distribution of its product Super-Flux. Super-Flux is an agent for intensifying fuel oil. By its de-emulsifying action, suspended globules of water in the oil are released and settled at the bottom of storage tanks. Super-Flux used regularly prevents further formation of sludge and eliminates periodic tank clean out. Many companies are using Super-Flux to reclaim the heavy sludge that has accumulated in the bottom of storage tanks. For further information address The Elliott Chemical Co., Struthers, Ohio.

"FEROX"

From a formula extensively used in Germany before the war, an economical new cutting oil which it is claimed eliminates the need of further rust prevention treatment for tools, materials and machinery is now being marketed in this country under the name of Ferox.

For most metals it is used one part Ferox Cutting oil to 49 parts clear water. For use on cast iron and malleable iron, one part Ferox Cutting Oil is used with 33 parts of clear water. For operations which call for threading or polishing, Ferox is used—one part Ferox to 35 parts clear water.

Actually, a homogeneous combination is achieved when Ferox Cutting Oil is mixed with water. It is sold in 5 gallon cans and 55 gallon drums by Beacon Rust Proofing Company, 19 West 31st Street, New York, New York.

LIQUID WAX LUBRICANT

A new liquid wax for use as a lubricant in the manufacture of metal items by the impact extrusion process has been developed by the makers of Johnson's Wax. It is being marketed as Johnson's LW #20 Wax.

In impact extrusion a waxed metal slug is placed in a die and struck a single, hard blow with a punch, causing the metal to flow out of the die and shoot up the sides of the punch to form a perfect tube. Typical articles produced by this process are collapsible tooth paste and shaving cream tubes and condenser cans.

The great heat generated in the process and the need for complete freedom of flow require an extremely efficient and rugged lubricant. Johnson's LW#20 Wax meets these requirements, giving a much more even coat than oils and tallows formerly used. It remains in place under the terrific heat and does not dissipate itself—thus cutting the number of rejects due to scoring caused by imperfect lubrication.

Development work on this process has been done by Johnson's chemists in cooperation with metallurgists at the Edgewater, N. J., plant of the Aluminum Company of America. Further information on LW#20 Wax can be obtained by writing to Product Finishes Department, S. C. Johnson & Son, Inc., Racine, Wisc.

"CLEAN OIL"

Volume 4 No. 1 of *Clean Oil*, a quarterly publication of Honan-Crane Corporation, just off the press, presents an unusually interesting case history of oil purification and how it solved several major problems for a Canadian plant producing styrene and other chemicals derived from petroleum crude.

This case history tells how Purifiers, installed on 43 engines, have extended engine overhaul periods from 5,000 to 10,000 or more hours, cutting the labor bill and downtime for engines in half. Parts replacement costs also have been greatly reduced. The total purification cost figures about $1 per week per engine.

The booklet devotes seven of its eight pages to discussion of this one plant's problems. The story gives complete and comprehensive information about this particular installation, with a wealth of detail that makes the findings applicable to operations in many fields. Included also is a complete description of the construction and features of Honan-Crane Purifiers. Copies of *Clean Oil* are available on request to Honan-Crane Corporation, 818 Wabash Ave., Lebanon, Indiana.

New Houghton Plant

Toronto — A pre-war dream became a post-war reality when E. F. Houghton & Co. of Canada, Limited, manufacturer of industrial oils, chemicals and leathers, began operations in its new Toronto plant on July 15, under the direction of E. H. MacInnis, Vice-President and Director of Sales.

The new plant, an affiliate of E. F. Houghton & Co., of Philadelphia, will specialize in the manufacture of metal working products such as carburizers, quenching oils, cutting oils, heat treating salts and drawing compounds, according to G. W. Pressell, Houghton Executive Vice-President and President of the Canadian company. Textile processing oils for wool, cotton and synthetic yarns and surface active agents also will be manufactured, as well as industrial lubricants and mechanical leathers.

Located at 100 Symes Road in Northwest Toronto, the new plant property covers 2½ acres of ground and is geographically situated so as to take full advantage of both rail and motor shipping facilities.

The Houghton Canadian sales organization today includes twelve representatives covering all of Canada from Vancouver to and including the Maritime Provinces. These men have an aggregate of 150 years of sales and service experience. British Columbia is covered by Production Supply Co., Houghton representative in Vancouver.

Now, after war-time delays, Houghton is glad to be able to build its own new plant to keep pace with the growth of business in Canada.

BOOK REVIEWS

Wear and Lubrication of Piston Rings and Cylinders

By Dr. Reemt Poppinga
Published by the A.S.L.E. Chicago, Ill., 1948. 201 pages. Price $3.50 ($3.00 to members of the Society).

This outstanding book in the field of wear and lubrication was originally published in Germany by V.D.I. (Verein Deutscher Ingenieure). The translation for the Society was made by Dr. Edmund Kurz of Queens College, New York, with Professor Dudley D. Fuller of Columbia University acting as Technical Advisor.

The fundamental nature of this book in the field of wear as influenced by material structure and lubrication is extremely well delineated. Not the least of the book's value arises from the very extensive bibliography of related literature in the field which lists 636 references.

The book should be of value not only to the lubrication engineer but to all designers and operators faced with the problem of designing and maintaining equipment.

Chambers' Mineralogical Dictionary

Chemical Publishing Company, Inc. Brooklyn, New York, 1948. 47 pages and 40 colored plates. Price $4.75.

For those concerned with mineralogy and geology, this dictionary, with its numerous colored plates, is indeed a "must." Over 1400 mineralogical terms are included with listings of chemical composition, crystal form, physical and chemical properties, and occurrence and uses of the minerals.

The colored plates are extremely fine examples of the printer's art in very rich and natural coloring.

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CONDUCTIVE COATINGS
EXTREME PRESSURES
360 WILKES PLACE
SHARON, PENNSYLVANIA

NEWS OF THE SECTIONS

ST. LOUIS

The members and guests of this Section closed their 1947-48 season on May 18th, with an attendance of better than 50, the speaker of the evening being Professor L. M. Tichvinsky, of Washington University, on the subject of "Heavy Duty Bearings," dealing with general bearing performance, particularly in reference to heavy duty reciprocating type engines and illustrating with slides bearing failures and their analysis. Dr. Hersey of M. I. T. was in St. Louis and attended the meeting as a guest of Professor Tichvinsky. New officers for the coming season were elected. (See Section Officers page.) This Section organized approximately one year ago and has made a remarkable record. It has attracted some of the foremost authorities in the country on various subjects and its membership has increased rapidly. We are informed by Mr. T. V. Picraux, the newly elected Vice Chairman, that they expect to double their membership the coming season.

NEW YORK

This Section officially closed its 1947-48 season with a dinner meeting at Stouffer's Restaurant on May 11th. During the year the membership has been increased from 90 to 160 members. Following the dinner, a most interesting talk on "Development and Appraisal of Lubricant Testing Procedures" was presented by Mr. R. C. Adams, U. S. Naval Engineering Experiment Station, Annapolis, Marylard. Mr. Adams emphasized particularly the statistical methods available for analyzing test results and the interest in this subject was evidenced by the great amount of discussion following the presentation of the paper. Among the guests present were six from Central and South America and one from South Africa. The meeting closed with the election of Officers for the 1948-49 season. (See Section Officers page.)

BUFFALO

The June meeting of this Section was an enjoyable social affair. Thomas J. O'Rourke, Chairman of the Committee for the evening, did an excellent job, from the refreshments which preceded the meeting to the finad good-night. 46 members and guests gathered at the Automobile Club of Buffalo, situated at Clarence, N. Y., for a fried chicken dinner and a very interesting evening. It was regretted that the Canadian members and friends were unable to be present. Mr. Norm Weiss, a strolling accordianist, entertained and at the conclusion of the dinner he was assisted by Max Winkler, who was celebrating his 65th birthday anniversary. Max favored with some very entertaining whistling and magic stunts. Mr. Paul Cardeaux, whose range of voice includes both tenor and bass, sang several familiar songs in a very stirring manner. This was followed by group singing of popular numbers, and an opportunity for informal chats and getting acquainted. The first fall meeting will be held on Wednesday, September 15th, at the Westbrook Hotel in Buffalo. National President of A.S.L.E., George L. Sumner, will be the guest, as will Anthony J. Zino, Society Membership Chairman, who will give an illustrated lecture on "Hydraulic Systems." The results of the letter ballot for officers for the coming year will be announced at the September meeting.

Credit goes to the Indianapolis Section for electing the first Section Editor who will be responsible for relaying to the central office the latest news of Section events, coupled with their schedule of meetings and events. Mr. H. E. Nicholson of The Texas Company was elected to this post. We hope it will be possible for all Sections to appoint similar duties to one of their members.

INDIANAPOLIS

The last meeting of the season was held on May 24th at the Severin Hotel, with no outside speaker scheduled. It was a purely business meeting where plans were made for the coming season and various other matters of importance to the Society were discussed. It was decided to change their election dates prior to April 10th so that the incoming officers could attend the conventions. The first fall meeting was set for September 27th, with plans as yet incomplete.

NORTHERN CALIFORNIA

The June 3rd meeting of this Section, held at Treasure Island, was preceded by a turkey dinner. Chairman, H. G. Isbell presided. Mr. Paul Ruedrich introduced the speaker of the evening, Dr. U. B. Bray, President and Research Director of the U. B. Bray Co., Los Angeles, Calif., who gave a most interesting discussion on "Development and Use of Additives in Lubricating Oils." Dr. Bray high-lighted his talk with many interesting demonstrations. Commentators were Mr. Bondi and Mr. Walters of Shell Research Corp. The next technical session will be held in October. Plans are now under way for a social meeting some time during the month of August.

CLEVELAND-YOUNGSTOWN

The Section held its final business meeting of the year at the Lubrizol Corp., Wickliffe, Ohio. Prior to the meeting, a dinner was attended by 71 members and guests at the Euclid Shore Club, near Wickliffe, after which a well-organized trip was conducted through the Lubrizol Corp., where laboratory and manufacturing processes in the making of engine oil additives and gear lubricant additives were inspected. Later in the evening, a question and answer period was held. New offi-

(*Continued on page* 184)

A.S.L.E. Section Officers

Baltimore:
Chair., V. A. Ryan, Crown Cork & Seal Co., Inc., Eastern Ave. & Kresson St., Baltimore 3, Md.
V. Chair., A. E. Cichelli, Bethlehem Steel Company, *802 E Street, Sparrows Point 19, Md.
Secy.-Treas., P. Raymond Staines, The Davison Chemical Corp., Curtis Bay Plant, Baltimore 3, Md.

Buffalo:
Chair., K. E. McHenry, Bethlehem Steel Co., Hamburg Turnpike, Lackawanna, N. Y.
Co-Chair. (Canada), T. A. Marshall, Steel Co. of Canada, Ltd., Wilcox, Hamilton, Ontario
Co-Chair. (U.S.A.), A. E. Mould, Tidewater Associated Oil Co., *22 Highland Drive, Williamsville, N. Y.
Secy., Nathan Morrell, Eastman Kodak Co., 333 State St., Rochester 4, N. Y.
Treas., George Findlay, Republic Steel Corp., 1175 S. Park Ave., Buffalo 20, N. Y.

Chicago:
Chair., N. C. Penfold, Armour Research Foundation, 35 W. 33rd St., Chicago 16, Ill.
V. Chair., C. E. Schmitz, Crane Packing Co., 1800 Cuyler Ave., Chicago 13, Ill.
Secy-Treas., D. S. Gray, Armour Research Foundation, 35 W. 33rd St., Chicago 16, Ill.

Cleveland-Youngstown:
Chair., Edwin Crankshaw, Cleveland Graphite Bronze Co., 17000 St. Clair St., Cleveland 10, Ohio
V. Chair., Charles A. Geisinger, B. F. Goodrich Co., 500 S. Main St., Akron 18, Ohio
Secy., Charles H. Frazier, The Torrington Co., 16004 Detroit Ave., Cleveland 7, Ohio
Treas., J. W. Kasmark, Lincoln Engineering Co., *596 E. 103rd St., Cleveland, Ohio

Dayton:
Chair., R. F. McKibben, National Cash Register Co., *241 N. Smithville Rd., Dayton 3, Ohio
Secy.-Treas., R. Lyle Brace, Brace Engineering Co., 440 E. Schantz Ave., Dayton 9, Ohio

Detroit:
Chair., P. W. Uhl, Detroit Diesel Engine Div. G.M., 13400 W. Outer Dr., Detroit 23, Mich.
V. Chair., P. D. Wright, Timken Detroit Axle Co., 100 Clark St., Detroit 32, Mich.
Secy., James W. Hopkinson, Penn Petroleum Corp., 5690—12th St., Detroit 8, Mich.
Treas., B. B. Phelps, Detroit Transmission Div., G.M.C., *2156 Cadillac Blvd., Detroit 4, Mich.

Indianapolis:
Chair., I. S. Bigger, Socony-Vacuum Oil Co., Inc., *3710 Central Ave., Indianapolis, Ind.
V. Chair., D. H. Wilson, Continental Steel Corp., South Plant, Kokomo, Ind.
Secy.-Treas., J. E. Burns, Jr., Crescent Oil Co., 514 W. Wyoming St., Indianapolis 2, Ind.

Los Angeles:
Chair., Milton A. Wise, General Petroleum Corp., 108 W. 2nd St., Los Angeles 12, Cal.
V. Chair., Peter Kyropoulos, California Inst. of Technology, 1201 E. California St., Pasadena 4, Cal.
Secy.-Treas., Richard L. Engel, Allis-Chalmers Mfg. Co., *800 S. Abbot Ave., San Gabriel, Cal.

Milwaukee:
Chair., Alvin E. Boie, Allis-Chalmers Mfg. Co., *6921 W. Rogers St., West Allis 14, Wisc.
V. Chair., Richard D. Bussard, Ladish Co., 5481 S. Packard, Cudahy, Wisc.
Secy., H. P. Hofmeister, Socony-Vacuum Oil Co., *2355 N. 82nd St., Wauwatosa, Wisc.
Treas., Darryl W. Johnson, Standard Oil Co., 414 W. Michigan St., Milwaukee 1, Wisc.

New York:
Chair., W. E. Campbell, Bell Telephone Laboratories, Murray Hill, New Jersey
V. Chair., Edward H. Erck, Bendix Aviation Corp., Teterboro, New Jersey.
Secy., John C. Vangundy, The Texas Co., 135 E. 42nd St., New York 17, N. Y.
Treas., Aubrey Setzer, Colgate-Palmolive-Peet Co., *P. O. Box 124, Metuchen, New Jersey

Philadelphia:
Chair., W. P. Kuebler, Westinghouse Electric Corp., *2334 Franklin Ave., Secane, Pa.
V. Chair., P. P. Teal, Alemite Co. of E. Pa., 704 N. 16th St., Philadelphia, Pa.
Secy-Treas., T. B. Ryan, Dingle-Clark Co., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.
Secy-Treas., K. E. Simminger, Bowser, Inc., 521 Arch St., Philadelphia 6, Pa.

A.S.L.E. National Committee Chairmen

Awards:
T. B. RYAN
Dingle-Clark Co.
Philadelphia 3, Penna.

By-Laws:
D. E. WHITEHEAD
Carnegie-Illinois Steel Co.
Pittsburgh, Pa.

Education and Training Program:
D. D. FULLER
Dept. of Mechanical Engineering
Columbia University
New York 27, N. Y.

Finance:
B. H. JENNINGS
Northwestern Technological Institute
Evanston, Ill.

Industrial Membership:
W. F. LEONARD
Room 1708, 343 S. Dearborn St.
Chicago 4, Ill.

Membership:
Co-Chairman, FRANK ROSS
E. F. Houghton & Co.
Cleveland 3, Ohio
Co-Chairman, WM. P. YOUNGCLAUS
2114 Fir St.
Glenview, Ill

New Sections:
NATIONAL OFFICE
Chicago 4, Ill.

Program, Planning and Publications:
Co-Chairman, ALLEN F. BREWER
The Texas Co.
New York 17, N. Y.
Co-Chairman, M. E. MERCHANT
Cincinnati Milling Machine Co.
Cincinnati 9, Ohio

Project and Publicity:
E. M. KIPP
Aluminum Research Labs.
New Kensington, Pa.

Membership in the Society is in several grades as defined below. Assignment to grade is made by the Admissions Committee or Board of Directors on the basis of information submitted or supplied by references.

MEMBERS—$10.00

Members shall be: (1) persons not less than twenty-four years in age who are engaged in research and instruction at technical schools, universities and various publicly and privately supported institutions in the field of lubrication; or (2) persons not less than twenty-four years in age who have occupied recognized positions as Lubrication Engineers for a period of three or more (not necessarily consecutive) years prior to date of admission, involving the responsibility for or supervision of the development, selection, field use and application of lubricants as differentiated from other activities; or (3) persons not less than twenty-four years in age who are indirectly concerned with the field of lubrication, but possessing other qualifications of experience, knowledge and accomplishment, have manifested a particular interest in the purposes and welfare of the Society, to the extent that their membership would be a valuable contribution to the successful functioning of its activities.

JUNIOR MEMBERS—$5.00

Junior Members shall be: persons less than twenty-four years in age, and those who do not completely fulfill the membership requirements for Members.

INDUSTRIAL MEMBERS

Industrial members are such persons or organizations as may be interested in and desire to contribute to supporting the purposes and activities of the Society. The fees paid by an industrial member in general will not be allowed to exceed $200.00 per year.

Northern California:	Chair., H. G. Isbell, Industrial Laboratory, U. S. Navy Yard, Mare Island, Cal. V. Chair., John Boyce, Food Machinery Corp., *1770 Cleveland Ave., San Jose, Cal. Secy.Treas., A. S. Horwitz, E. F. Houghton & Co., Quint & Davidson Sts., San Francisco, Cal.
Pittsburgh:	Chair., W. E. Elliott, Carnegie Illinois Steel Co., *837 Middle, North Braddock, Pa. V. Chair., Wayne S. Fuhr, Hanna Coal Co., *RFD No. 1, Bridgeport, Ohio Secy.-Treas., H. A. Goddard, Gulf Oil Corp., Gross St. & P.R.R., Pittsburgh 6, Pa.
St. Louis:	Chair., J. F. Palmer, Jr., Monsanto Chemical Co., 1700 S. 2nd St., St. Louis 4, Mo. V. Chair., T. V. Picraux, Lincoln Engineering Co., 5703 Natural Bridge Ave., St. Louis 20, Mo. Secy.-Treas., Henry M. T. Harris, National Bearing, Div. Brake Shoe, *2837 Manderly, Brentwood 17, Mo.

*Denotes Residence Address Preferred.

AUGUST COVER, L. E.—ST. LOUIS

St. Louis, the home of one of the newer Sections of A.S.L.E., originated as a French post for the Indian trade in 1764. It is proud of being an industrial center, served by 18 trunk line railroads and the important Mississippi waterway system, which serves river ports of 17 States and reaches the ocean through New Orleans and the Great Lakes ports. The many advantages of the city have attracted scores of new industries to St. Louis, adding to its already large and diversified industrial picture. Among those of interest in the Lubrication field are Monsanto Chemical Co., manufacturers of additives, and the Lincoln Engineering Company, makers of automatic lubrication equipment. The A.S.L.E. St. Louis Section was organized in May, 1947, and has grown into one of our leading Sections. This group reflects the progressive spirit of St. Louis.

NEWS OF THE SECTIONS

(*Continued from page* 182)

cers were elected for the season of 1948-49. (See Section Officers page). On Friday, June 25th, the Section held its Third Annual Golf Party and Dinner at the Tippecanoe Country Club near Youngstown, Ohio. Given perfect weather and a beautiful course, followed by an excellent dinner, the party was a success in every way. For the second successive year, H. W. (Champ) Jones of Penola, Inc., captured the prize for low gross with a mighty 83.

Frank Sargent's Program Committee is already busy with plans for the coming season. The first event will be a combination golf party and clam bake at the Firestone Country Club in Akron, Ohio, on Thursday, September 16th. Mr. Sargent claims that this will top all preceding parties.

LOS ANGELES

The last meeting of the season was held on Tuesday, June 15th, at the Ethyl Corp. Auditorium at 8:00 P. M. The subject of "Engineered Automotive Lubrication" was ably presented by Mr. Robert E. Rowley, Senior Mechanical Engineer of the Los Angeles Dept. of Water and Power. Mr. Rowley has made a long study of the role played by lubrication in preventive maintenance and has delivered many papers before the Society of Automotive Engineers. In his discussion, Mr. Rowley brought out interesting points regarding complete management control of lubrication in relation to preventive maintenance, coupled with statistics showing operating results representing millions of miles of general fleet services and discussed these results in the light of laboratory and shop analysis. A short business session was held and plans are under way for the resumption of the Section activities in September.

PITTSBURGH

The May meeting of this Section was held in Wheeling, W. Va., Friday evening, May 21st. Following the dinner, Chairman George Sumner conducted the first session and after a general discussion of Society affairs, resigned as Chairman inasmuch as his duties as President of the National organization consumed so much of his time. Mr. William Elliott, former Vice Chairman, automatically became the new Chairman of the Section and Mr. Wayne S. Fuhr was unanimously chosen for the office of Vice Chairman. The technical session was conducted by Mr. Wayne Ritter and Mr. F. R. Magill who handled very ably the subject of "Oil Seals and Their Application to Industrial Machinery." The next meeting will be on Friday, September 17th. The subject will be "Refining and Manufacturing of Lubricating Oils," by Mr. F. C. Savage of the Socony-Vacuum Oil Company. The place of the meeting will be determined at a later date.

BALTIMORE

The June meeting of the Section closed the activities for the season. A short business session was held, after which the speaker of the evening, Mr. Henry Jones, Asst. Supt. of the Patapsco & Back River Railroad, was introduced by Vice Chairman Cichelli. Mr. Jones presented an interesting talk, supplemented with slides on "Railroad Diesel Engine Lubrication." The discussion following this paper attested to the interest aroused. Mr. Paul Chappell discussed "The Advantages and Hazards of Reducing the S.A.E. Brands of Motor Oils." The talk evoked much comment. The following calendar of events has been announced:

Friday, September 24th:

First meeting of the fall season. Speaker L. Bode, Supt. of Equipment, Baltimore Transit Co., "Fleet Maintenance."

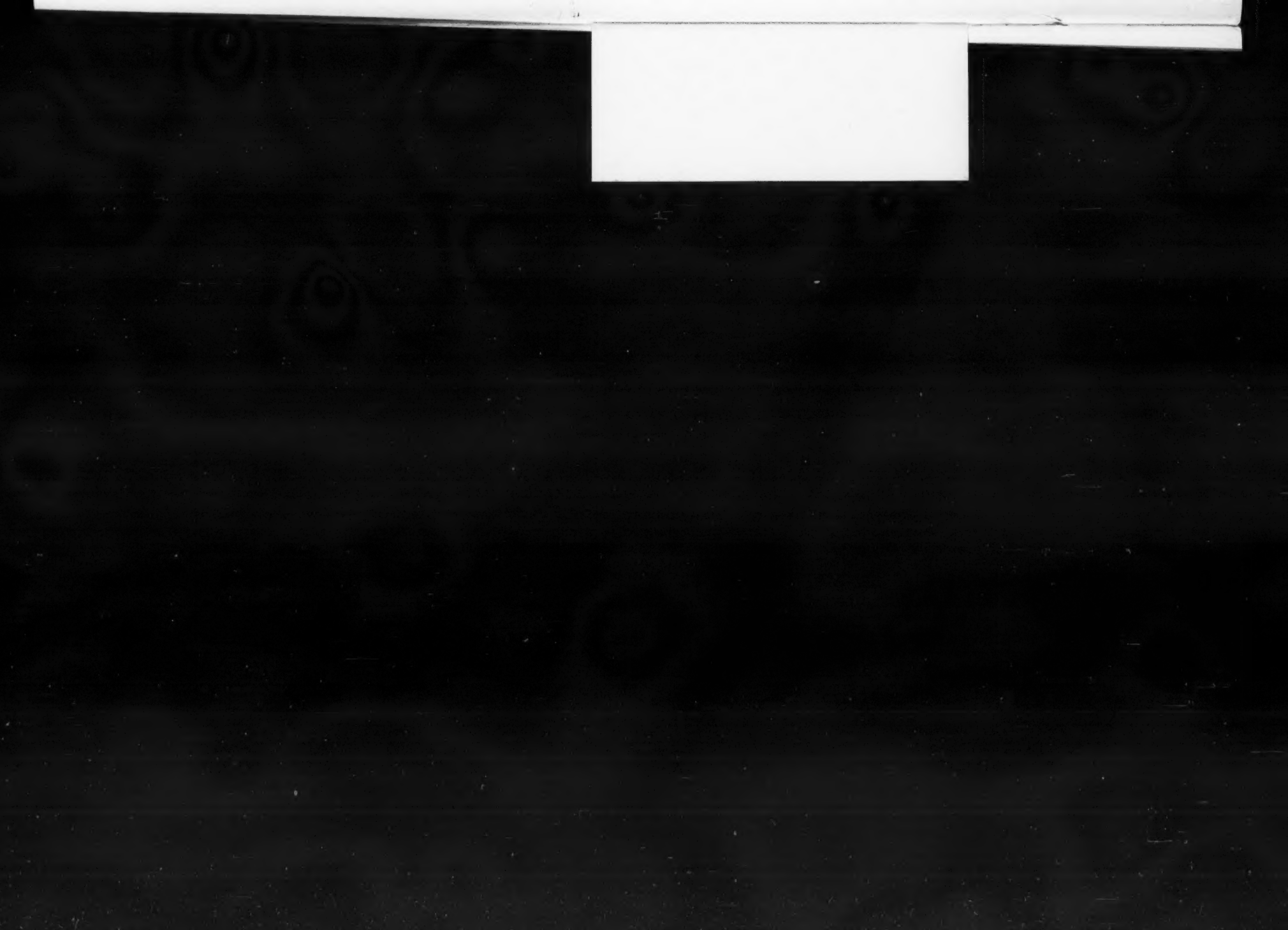
Friday, October 29th:

Speaker Norman Klein, U. S. Army Ordnance Technical Div., Fuels & Lubricants Sect. "Winterizing Army Equipment."

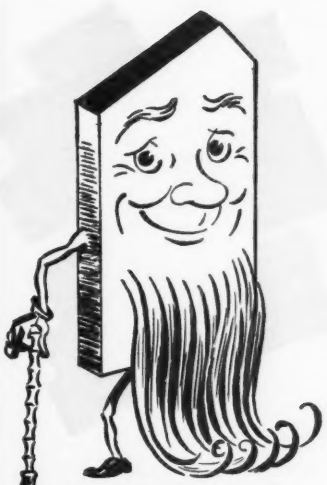
Friday, November 19th:

Speaker Dr. Charles E. Waring, Director Research Davison Chemical Corp. "Refrigerator Maintenance Lubrication."

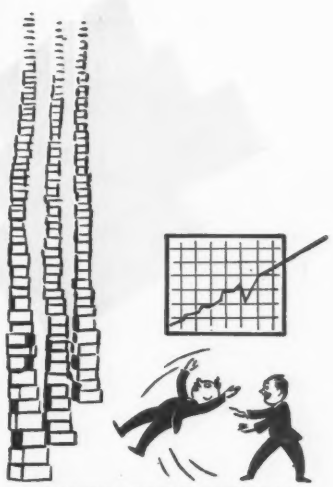
We take pleasure in extending our compliments to the Officers, Directors, and Members of this, our newest Section, for the growth and progress since their organization.



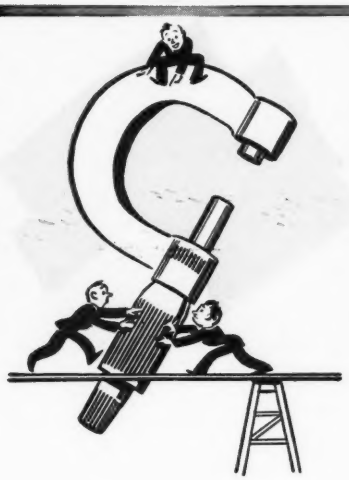
WHY IT PAYS TO USE THE *RIGHT* CUTTING OIL



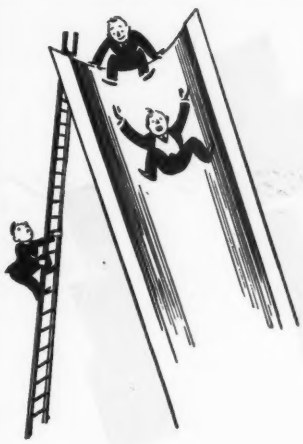
LONGER TOOL LIFE



HIGHER PRODUCTION



CLOSER TOLERANCE



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(*Continued from page* 165)

ticles is used to advantage in the refining of gold and other precious metals. There is a close relationship between emulsifying, film forming, foam forming and wetting characteristics. Some of these are closely related to detergency, and several detergent tests are mentioned in the literature. The foaming test established by the Coordinating Research Council for gear lubricants is fairly well standardized and has been used with considerable success in evaluating the foaming characteristics of cutting fluids. There is no record that established surface tension measuring techniques have been successfully applied to the evaluation of these characteristics in cutting fluids.

As has been mentioned before, there is little to be proud of in the record of shop testing techniques and methods as applied to cutting fluids. The very complexity of our operations and the very large number of variables entering into machining processes gives some excuse, but our carelessness in dealing with this important phase of our operations must be admitted and deplored. Skillful problem analysis, careful project planning, intelligent operation, factual observation, accurate recording, and sound conclusions cannot be expected from the personnel assigned to do this work, and the time in which they are given to do it in the average plant. Our only hope is that management will learn to respect the problems, and that operators will come to accept their fair share of the responsibility for conditions which are usually blamed on the supplier. Machine problems must in large part be solved at the machine by the respectful and intelligent cooperation of tool and lubrication engineers.

The astounding array of negatives, which always results when we question ourselves regarding our knowledge of metalworking procedures and cutting fluid application, should challenge the cutting fluid user as well as the supplier as both must share the responsibility for the present regrettable lack of information.

The greatest single handicap to our immediate progress is the lack of appreciation and acceptable explanation of the mechanisms of metalcutting. The extremely limited number of people who over the years have dealt with this problem are to be congratulated, but they have been all too few considering the importance of the problem. How can we understand that which we cannot perceive, and how can we measure that which we cannot comprehend. If operating engineers will align themselves with supplier engineers in an informed and intelligent attack on these basic problems, satisfactory tests and operational procedures will follow as a matter of course.

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A Translation of the Complete Results of a Research Program to Investigate the Problem of Wear in all of its Ramifications Conducted at the University of Dresden.

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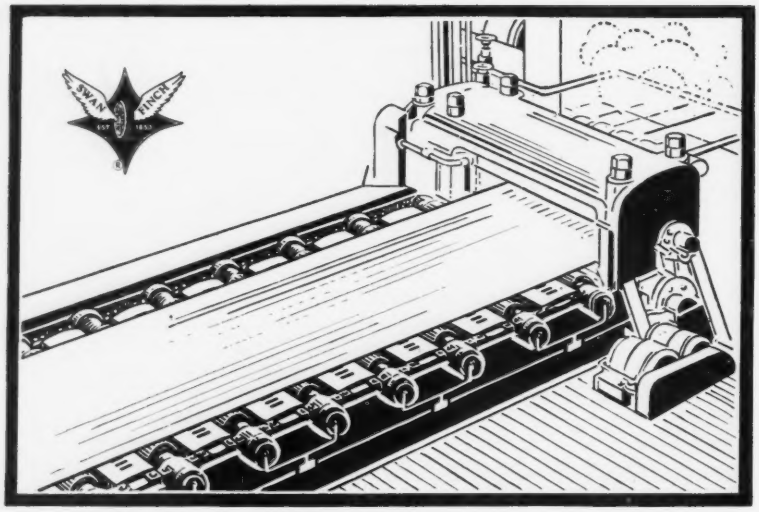

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(*Continued from page* 178)

Like earlier processes, both make gas from coal or coke, oxygen and steam. Both processes are described briefly.

BRAZIL PLANS NEW PETROLEUM REGULATIONS FOR REFINERS

Anon.—pp. 206, 208

The projected new petroleum law would limit refining and transportation of Brazil's oil. Essentials of the project are: (1) Exploitation of Brazil's oil is a government responsibility. (2) Both foreign and domestic firms may be authorized to seek out and drill for Brazilian oil, but only companies with at least 60 per cent Brazilian voting stock may refine and transport it. (3) Foreign as well as domestic companies may be granted the right to market national petroleum for local sale. (4) Exportation would be permitted to either foreign or domestic firms, but only after certain conditions of national supply are met.

SURFACE ACTIVE AGENTS

Porter, R. W.—p. 166

WETTING AGENTS

Porter, R. W.—p. 168

First note. Three new groups of surface active agents have been added to the line of chemicals made by Armour & Co. Having the brand names of Ethomeens, Ethomids, and Ethofats, these materials are derivatives of fatty-acid amines. Second note. An addition to its line of surface active agents has been announced by the Emulsol Corp. Known as Emcol 5100, this wetting agent is of the alkanolamine condensation type. It is said to be compatible with both anion and cation, active detergents, and may be used in mildly acid or alkaline ranges.

Corrosion and Material Protection, Vol. V, No. 1, January-February, 1948

CLEAR COATINGS WITH RUST PREVENTIVE PROPERTIES

Sel.ei, H. & Lieber, E.—pp. 10-12

The present paper reviews the background and initial development of transparent and readily removable coatings having rust preventive properties.

Petroleum Equipment, Vol. XI, No. 1, January, February, March, 1948

LIQUID LEVEL INDICATION AND CONTROL

Anon—p. 22

A new electronic instrument is described that utilizes an efficient Gamma Ray Detector and the tremendous penetrating power of gamma rays emanating from a small Radium source to determine liquid level without any connections originating inside the containing vessel. Used in conjunction with the manufacturer's Electronik Recording Controller, the instrument provides a means of remote, continuous, liquid level indication and control.

CONTINUOUS GREASE PROCESS

Anon.—p. 76

A new process for manufacturing greases and blending oils which enables grease manufacturers to eliminate all batch processing is now available. The entire system is automatic and, once set up, produces a homogeneous, perfectly uniform product day after day. Standard capacities process up to 1,000 gallons per hour. The heart of the new process is the "Temperer" which thoroughly processes all the ingredients under temperature control. It blends, mills, and homogenizes all the ingredients and passes them along to packaging units without the need of additional pumps. Characteristics of the finished product are under control at all times.

Power Generation, Vol. LII, No. 1 January, 1948

ELIMINATING FUEL WASTE

Elfreth, H. D., & MacHarg, A.—pp. 82, 84

To eliminate fuel waste and determine the savings of fuel possible in any particular plant, the authors recommend: 1) to maintain a high feeding temperature, 2) to recover the heat in boiler blowoff water, 3) to return all condensate to the boiler, 4) to reduce moisture content of steam, 5) to check boiler water treatment, 6) to keep on the watch for steam and hot water leaks, 7) to keep all piping and steam using equipment properly insulated, and 8) to practice preventive maintenance.

CORROSION IN BOILER FEEDWATER TREATING SYSTEMS. IV.

Collins, L. F.—pp. 106, 108

In this fourth and last article of the series, the author discusses especially the systems employing zeolite, acids, degasification and reports tests to evaluate comparative corrosion resistance of materials used in deaerating heater trays, vent condenser tubes, and water heater tubes. The first, second and third parts of the series appeared in the October, November and December, 1947, issues of this magazine.

IMPORTANCE OF PROPER DIESEL LUBRICATION

Trail, T.—pp. 110, 112, 114

The lubrication problems in the operation of Diesel engines, formation of sludge, effect of dust and other factors involved in proper lubrication are discussed.

World Petroleum, Vol. XIX, No. 2 February, 1948

FIRST TURNAROUND OF SMALL TCC (THERMOFOR CATALYTIC CRACKING) UNIT

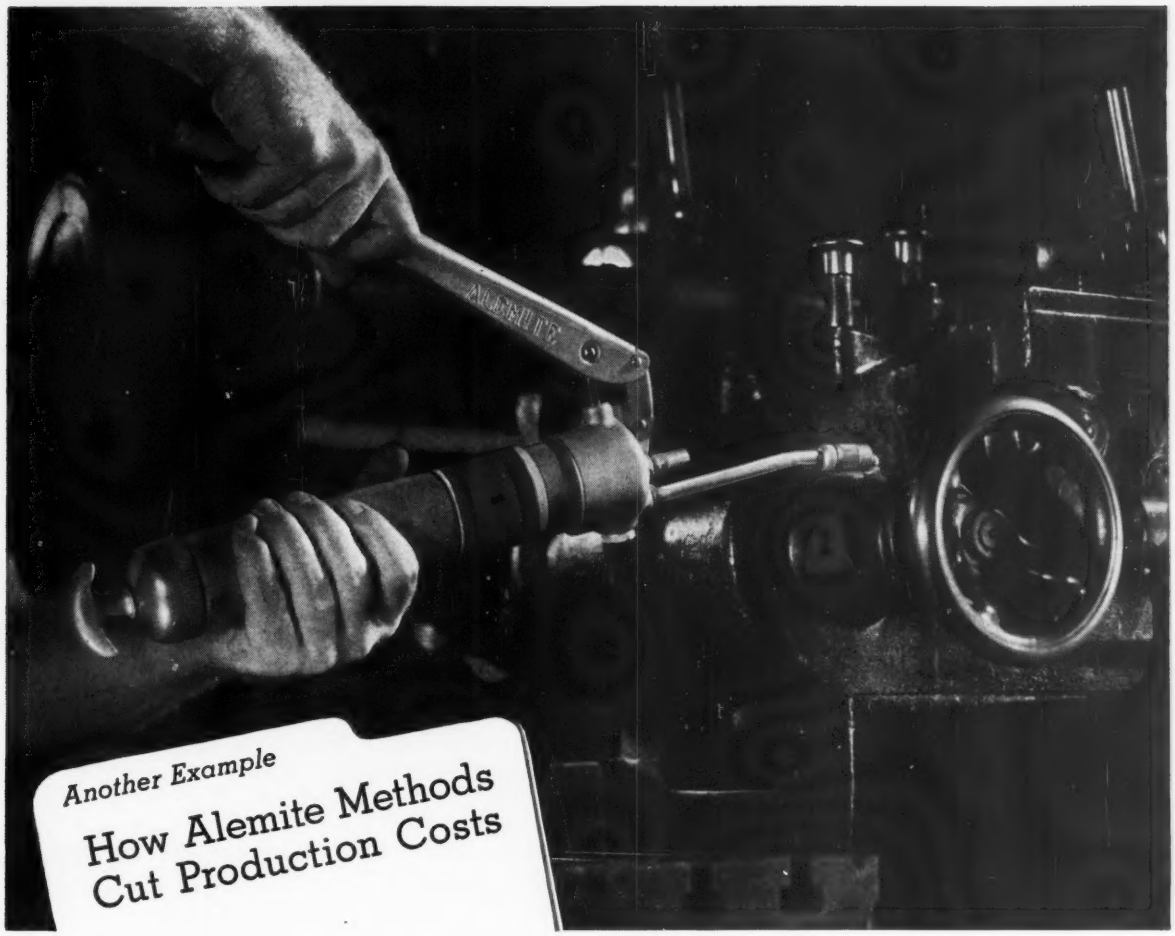
Pfarr, J. S.—pp. 59-61

The first turnaround of the Leonard TCC unit has recently been completed with an expenditure of only 4,557 manhours. Following an initial run of 222 days, during which time the unit had an on-stream efficiency of 96.4 per cent, a complete inspection of the plant was begun on Oct. 27, 1947. Operation of the plant was resumed on Nov. 6, 1947. The items of work performed during the shutdown are described, and the results of the inspection of equipment are indicated.

NPC ADOPTS FUEL CONSERVATION PROGRAM

Anon.—p. 62

Meeting here on January 22, 1948, the National Petroleum Council (NPC) adopted the report of its special committee which has been considering measures for avoiding a shortage of fuel oil. The committee's recommendations pertaining to the fuel conservation program, as approved by NPC, are summarized.



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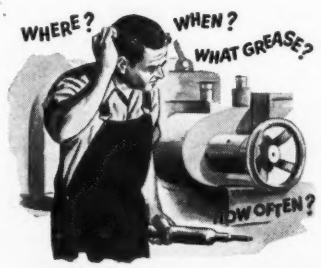

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Bibliography of paper entitled

"NOTES ON HEAVY-DUTY DIESEL ENGINE BEARINGS"

by L. M. Tichvinsky

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Trans. A.S.M.E., May, 1947, Vol. 69, No. 44, p. 371.

3) Performance of Oil-Ring Bearings, by G. B. Karelitz. Trans. A.S.M.E., Vol. 52, 1930.

4) Bearings and Bearing Metals, by Lt.-Cmdr. B. O. Brouk. Journal of the American Society of Naval Engineers, Aug., 1946, Vol. 58, No. 3.

5) Diesel Engine Bearings, by L. M. Tichvinsky. Mechanical Engineering, May, 1945, Vol. 67, No. 5, p. 297.

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7) The influence of the Centrifugal Process on the Physical Properties of some Non-Ferrous Alloys, by W. W. Edens and J. F. Klement. Trans. A.F.A., December, 1944, p. 393-406.

8) Spinning Seeds of Centrifugal Casting Machines, by F. G. Carrington. Trans. A.F.A., December, 1944, p. 333-348.

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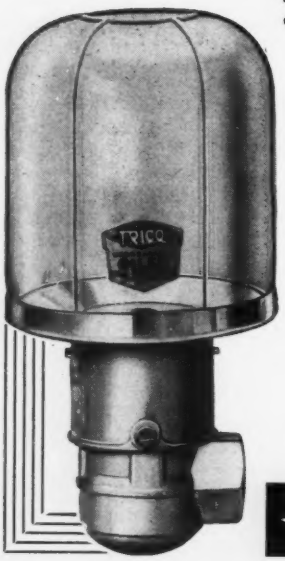

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(*Continued from page* 177)

are in excellent condition at time of top overhaul, which takes place about every 18 months (91,000 hours), or the equivalent of over 2,500,000 road miles.

A review of 150 consecutive samples reveals the following distribution as to types of service.

Type of Operation

	NO.	PER CT.
Passenger Cars	32	29
Taxicab	11	
Buses	22	57*
Trucks (Over the Road)	63	
Local Delivery	15	10
Aircraft	6	4

* Includes 12 Diesel Engines.

Of these engines, 76% were equipped with oil filters, and the following types of oil were used.

Types of Oil Used

	NO. OF SAMPLES	PER CT.
Heavy Duty	91	61
Premium	41	28
Regular	17	11

Since most of the engines were in fleet service, heavy duty oils predominate.

The following table indicates the relative degree of oil oxidation vs. contamination. Since oil increases in viscosity on oxidation, it can be assumed that samples showing a decrease or no change in viscosity have not oxidized.

Viscosity

	NO.	PER CT.
Samples Showing Decrease	93	82
Samples Showing No Change	29	
Samples Showing Increase—		
Due to Contamination	17	11
Due to Oxidation	10	7

This table shows that when good quality premium or heavy duty oils are used, bulk oil oxidation certainly is not a serious factor. However, the table shown below indicates that nearly 50% of the samples contained 1% or more of total solids, pointing toward a relatively high degree of contamination in these samples.

Insolubles in Oil

	NO. OF SAMPLES	PCT. OF SAMPLES	AVG. MILES	PCT. WITH FILTER
0.2% or less	20	13	2046	100
0.5% or less	42	28	2013	90
1.0% or less	68	46	1813	84
3.0% or less	126	83	1844	70
Over 3.0%	23	17	1723	73

The nature of the contaminants is revealed by the following tables:

Contaminants

Water

Samples with 0.2% or more	6 or 4%
Samples with less than 0.2%	143 or 96%

Dirt

Samples with excessive amount	8 or 5%
Samples with slight amount	10 or 7%
Samples with negligible amount	131 or 88%

Soot

Samples with excessive amount	12 or 8%
Samples with slight amount	16 or 11%
Samples with negligible amount	121 or 81%

Metal

Samples with excessive amount	44 or 30%
Samples with slight amount	29 or 19%
Samples with negligible amount	76 or 51%

These results show that metal and soot contamination predominate, and that an appreciable number of samples are affected.

Conclusions

A rapid, reliable, and significant used oil test has been developed. It has proved to be invaluable in diagnosing internal engine condition from used oil tests. It appears to be best adapted to the detection of contaminants in the oil which, according to present indications, are the primary source of engine troubles. There are undoubtedly many other oil test methods which could be used to provide the same information, and the methods described here are not suggested as substitutes for A.S.T.M. procedures where more precise determinations are essential. They are, however, admirably suited to the peculiar requirements of rapid, reliable and significant used oil inspection.

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Conveyor speed doubled, $12,000 labor saved with Farval

IN a plant with 110,000 feet of coal conveyor, the company employed 4 men per shift to hand-lubricate the 650 bearings on 17 conveyor drive units. Bearings frequently heated up or failed between oilers' visits. Other bearings were neglected while those in trouble were being nursed along. Conveyor speed had to be reduced and coal delivery slowed down.

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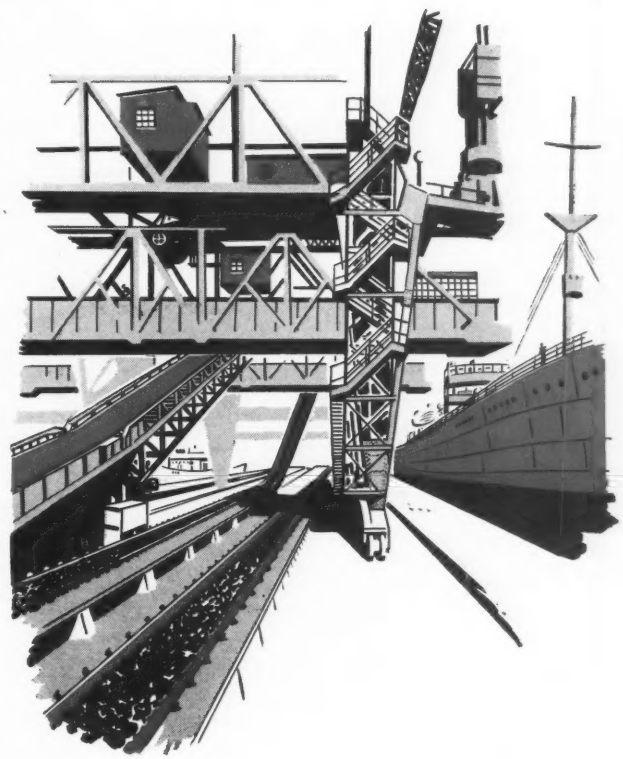
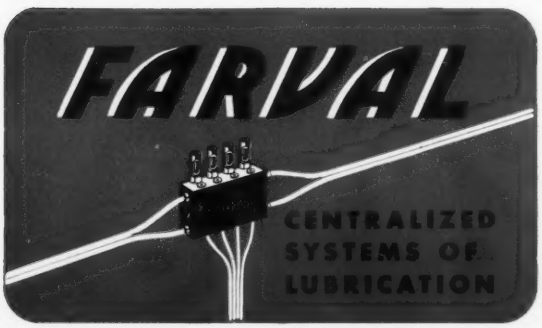
FARVAL—*Studies in Centralized Lubrication No. 92*





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